PB83-181834

Preliminary Operations Plan and Guidelines for the At-Sea Incineration of Liquid PCB (Polychlorinated biphenyl) Wastes

TRW, Inc.
Redondo Beach, CA

Prepared for

Industrial Environmental Research Lab.
Research Triangle Park, NC

Apr 82

U.S. Department of Commerce
National Technical Information Service
NTIS

EPA-600/2-82-068
April 1982

PB83-181834

PRELIMINARY
OPERATIONS PLAN AND GUIDELINES FOR THE AT-SEA INCINERATION OF LIQUID PCB WASTES

by

L.L. Scinto, P.A. Painter, A.M. Takata, and T.J. Hennings
TRW, Inc.
Environmental Division
One Space Park
Redondo Beach, CA 90278

Contract No. 68-02-3174
Work Assignment No. 55

EPA Project Officer: D.C. Sánchez

Industrial Environmental Research Laboratory
Office of Environmental Engineering and Technology
Research Triangle Park, N.C. 27711

U.S. ENVIRONMENTAL PROTECTION AGENCY
Office of Research and Development
Washington, D.C. 20406

REPRODUCED BY
NATIONAL TECHNICAL
INFORMATION SERVICE
U.S. DEPARTMENT OF COMMERCE
SPRINGFIELD, VA. 22161

TECHNICAL REPORT DATA
(Please read Instructions on the reverse before completing)

1. REPORT NO. EPA-600/2-82-068	2. ORD Report	3. RECIPIENT'S ACCESSION NO. PB83 181834
4. TITLE AND SUBTITLE Preliminary Operations Plan and Guidelines for the At-sea Incineration of Liquid PCB Wastes		5. REPORT DATE April 1982
		6. PERFORMING ORGANIZATION CODE
7. AUTHOR(S) T. J. Hennings, P. A. Painter, L. L. Scinto, and A. M. Takata		8. PERFORMING ORGANIZATION REPORT NO.
9. PERFORMING ORGANIZATION NAME AND ADDRESS TRW, Inc. One Space Park Redondo Beach, California 90278		10. PROGRAM ELEMENT NO.
		11. CONTRACT/GRANT NO. 68-02-3174, Task 55
12. SPONSORING AGENCY NAME AND ADDRESS EPA, Office of Research and Development Industrial Environmental Research Laboratory Research Triangle Park, NC 27711		13. TYPE OF REPORT AND PERIOD COVERED Task Final; 1-4/81
		14. SPONSORING AGENCY CODE EPA/600/13

15. SUPPLEMENTARY NOTES IERL-RTP project officer is David C. Sanchez, Mail Drop 63, 919/541-2547.

16. ABSTRACT The report is a preliminary operations plan and guidelines report for the disposal of polychlorinated biphenyl (PCB) wastes by at-sea incineration. The study was divided into two subtasks: Subtask A was the development of an inventory of government-owned PCB wastes suitable for at-sea incineration; and Subtask B was the development of operating plans and a schedule for an EPA-coordinated project to dispose of these wastes. Approximately 1.3 million gallons of government-owned liquid PCB wastes were identified, 425,000 gallons of which were considered to be immediately available for at-sea incineration. The operations plan addresses both land-based and at-sea operations. Land-based operations include waste collection and preparation, transportation to a processing facility, processing of wastes and containers, interim storage of bulk liquids, transportation to a ship loading site on the Gulf of Mexico, and ship loading. Incineration site selection, permit requirements, incineration procedures, and cargo tank decontamination are addressed for at-sea operations. The preliminary schedule for the disposal project shows 10 months from the decision to proceed with the project to completion of disposal operations.

17. KEY WORDS AND DOCUMENT ANALYSIS

a. DESCRIPTORS		b. IDENTIFIERS/OPEN ENDED TERMS	c. COSATI Field/Group	
Pollution	Incinerators	Pollution Control	13B	
Chlorine Aromatic Compounds	Waste Treatment	Stationary Sources		
Biphenyl	Transportation	Polychlorinated Biphenyls	07C	
Liquids	Bulk Storage	At-sea Incineration	07D	14G
Waste Disposal	Decontamination	Waste Collection	15E	

18. DISTRIBUTION STATEMENT Release to Public	19. SECURITY CLASS *(This Report)* Unclassified	21. NO. OF PAGES 121
	20. SECURITY CLASS *(This page)* Unclassified	22. PRICE

EPA Form 2220-1 (9-73)

NOTICE

THIS DOCUMENT HAS BEEN REPRODUCED FROM THE BEST COPY FURNISHED US BY THE SPONSORING AGENCY. ALTHOUGH IT IS RECOGNIZED THAT CERTAIN PORTIONS ARE ILLEGIBLE, IT IS BEING RELEASED IN THE INTEREST OF MAKING AVAILABLE AS MUCH INFORMATION AS POSSIBLE.

NOTICE

This document has been reviewed in accordance with U.S. Environmental Protection Agency policy and approved for publication. Mention of trade names or commercial products does not constitute endorsement or recommendation for use.

ABSTRACT

This document is a preliminary operations plan and guidelines report for the disposal of polychlorinated biphenyl (PCB) wastes by at-sea incineration. The effort on this study was divided into two subtasks. In Subtask A, an inventory of government-owned PCB wastes suitable for at-sea incineration was developed. Approximately 1.3 million gallons of government-owned liquid PCB wastes were identified in Subtask A, 425,000 gallons of which were considered immediately available for disposal by at-sea incineration. In Subtask B, operating plans and a schedule for an EPA-coordinated project to dispose of these wastes were developed. The operations plan addresses both land-based and at-sea operations. Land-based operations include waste collection and preparation, transportation to a processing facility, processing of wastes and containers, interim storage of bulk liquids, transportation to a ship loading site on the Gulf of Mexico, and ship loading. Incineration site selection, permit requirements, incineration procedures, and cargo tank decontamination are addressed for at-sea operations. The preliminary schedule for the disposal project shows a duration of 10 months from decision to proceed with the project to completion of disposal operations.

This report was submitted in fulfillment of Contract No. 68-02-3174, Work Assignment 55, by the Environmental Division of TRW, Inc., under sponsorship of the U.S. Environmental Protection Agency. This report covers the period 21 January 1981 to 12 June 1981, and work was completed as of 12 June 1981.

CONTENTS

Abstract. ii

1. Introduction 1

   1.1 Background. 1
   1.2 Purpose and Scope 3
   1.3 Organization. 3

2. Inventory of PCB Waste Stocks. 5

   2.1 Organizations Contacted 5
   2.2 Quantities and Locations of Waste Stocks. 6
   2.3 Detailed Description of Waste Stocks. 6

3. Land-Based Operations. 11

   3.1 Collection and Preparation of PCB Wastes. 11
   3.2 Transportation to Processing Facility 16
   3.3 Criteria for Selecting Processing Facility Locations. . . . 21
   3.4 Processing of Wastes and Containers 22
   3.5 Interim Storage of Bulk Liquids 34
   3.6 Transportation to the Ship Loading Site 36
   3.7 Ship Loading. 41
   3.8 Public Notification and Participation 45

4. At-Sea Operations. 47

   4.1 Incineration Site Selection 47
   4.2 Permit Requirements 49
   4.3 Incineration Operations 56
   4.4 Cargo Tank Decontamination 74

5. Logic Network and Schedule 77

   5.1 Critical Path Model 77
   5.2 Schedule. 79

References. 81

Appendices

A. Inventory of PCB Stocks. 84
B. Safety Plan for Incineration of Liquid PCBs Onboard the M/T Vulcanus 97

1. INTRODUCTION

1.1 BACKGROUND

Polychlorinated biphenyls (PCBs) are synthetic chlorinated organic compounds which have extremely high thermal and chemical stability. They have excellent electrical insulating properties, low volatilities, and high flash points. These characteristics make PCBs useful in numerous commercial applications, particularly as dielectric fluids in transformers and capacitors.

Commercial mixtures of PCBs are very complex, each containing many of the 209 possible PCB isomers and often organic solvents. Most individual PCB isomers are solids at room temperature, but commercial mixtures vary in consistency from mobile oils to viscous liquids. Common trade names for these mixtures include Arochlor, Inerteen, Kanechlor, and Pyranol.

PCBs are moderately acute toxicants. They are similar in their biological activity to the pesticide dichloro-diphenyl-trichlorethane (DDT). These chemicals are metabolized slowly and accumulate in fatty tissues of animals and humans. The known toxic effects of PCBs in humans include chloracne, skin pigmentation, swelling of the eyelids and excessive eye discharge. Animal reproduction is also known to be impaired by PCBs, and malformations have been reported. PCBs have exhibited carcinogenic effects in some animal species. The resistance of PCBs to degradation contributes to their persistence in the environment and enhances their availability for uptake by plants and animals, thereby causing them to enter the food chain.

Recognizing the environmental problems associated with the widespread use of chemicals such as PCBs, Congress, in 1976, passed the Toxic Substances Control Act (TSCA). Section 6(e) of TSCA required the Environmental Protection Agency (EPA) to regulate the marking and disposal of PCBs. It also provided for a ban on the manufacture and use of PCBs in other than a totally enclosed manner by 1 January 1978, a complete ban on manufacture by 2 July 1979, and a complete ban on distribution in commerce and processing by 1 July 1979. EPA was, however, authorized to grant exceptions to the ban rules under certain conditions.

On 31 May 1979, EPA promulgated the final rule ("PCB Regulations") under the authority of Section 6(e) of TSCA: Polychlorinated Biphenyls (PCBs) Manufacturing, Processing, Distribution in Commerce, and Use Prohibitions (40 CFR 761). This rule: 1) prohibits all manufacturing of PCBs after 2 July 1979; 2) prohibits processing, distribution in commerce, and use of PCBs except in a totally enclosed manner after 1 July 1979; and 3) authorizes certain exemptions. The PCB Regulations do not require removal of PCBs and PCB Items from service and disposal earlier than would normally be required. But, when PCBs and PCB Items are removed from service, disposal must be in accordance with the PCB Regulations. The PCB Regulations generally apply to any substance, mixture, or item containing greater than 50 ppm PCBs. However, a recent court decision on the 50 ppm rule may have the effect of requiring that substances containing less than 50 ppm of PCBs be regulated. This would increase the amount of PCBs which would eventually require disposal.

One of the methods for PCB disposal permitted in the PCB Regulations is incineration. Incineration is the preferred method for disposal of a number of chlorinated organic wastes because it is capable of essentially complete destruction of the toxic or hazardous constituents of the wastes, and is thus an ultimate disposal technology. Recently EPA tested and approved two land-based incinerators for the disposal of PCBs. However, it is not expected that the shortfall in PCB disposal capacity predicted by the Electric Power Research Institute (1) will be alleviated fully by these units.

Another method of disposing of PCB fluids is by non-thermal degradation methods. Recently some EPA Regions have approved one such non-thermal method, the PCBX process, for disposal of certain liquid PCB wastes.

An alternative to land-based incineration or non-thermal treatment is incineration at sea. At-sea incineration of organochlorine liquids has been practiced successfully in Europe for a number of years. In the U.S., organocholorine wastes were incinerated in the Gulf of Mexico on board the M/T Vulcanus in late 1974 (2) and again in early 1977 (3). Subsequently, stocks of U.S. Air Force Herbicide Orange were burned on the Vulcanus in the

Pacific Ocean (4, 5, 6, 7, 8). All U.S. burns were closely monitored by EPA. Monitoring results provided the technical basis for concluding that at-sea incineration is an environmentally acceptable alternative to land-based incineration for organochlorine wastes.

At-sea incineration is a technology which has the potential to increase PCB disposal capacity nationally, thereby relieving some of the expected shortfall in capacity. Although at-sea incineration is a proven technology, no attempts have yet been made to demonstrate that PCBs can be effectively disposed of in this manner.

EPA has received requests from various state and Federal agencies for assistance in disposal of government-owned PCB wastes. In addition, many organizations in the private sector are storing PCB wastes for disposal. At-sea incineration is being considered as a disposal method for these wastes.

Any person desiring to incinerate wastes at sea must first obtain a permit to do so as required by regulations under the Marine Protection, Research and Sanctuaries Act (MPRSA). An application for a permit to incinerate PCBs was submitted to EPA by the owners of the Vulcanus, and a permit was recently granted. Disposal of government-owned as well as private industry stocks of PCBs can be accomplished under the terms of this permit. Successful incineration of PCBs on the Vulcanus would not only serve to dispose of government stocks of PCBs; it would add at-sea incineration to the list of disposal options available to the owners of PCB wastes.

1.2 PURPOSE AND SCOPE

This resource document identifies government-owned stocks of PCB wastes which are available for disposal and presents a conceptual plan for destruction of these wastes by at-sea incineration. The document describes administrative, legal, and technical considerations which must be incorporated into the program planning. Based on these considerations, criteria and guidelines have been defined for functional tasks. When appropriate within the scope of this effort, specific operating plans have been described or recommended.

Complete definition of some program elements cannot be made at this time because of lack of information, possible or anticipated changes in the regulatory structure, or uncertainties in regards to the logistics of the disposal action. In these cases, guidelines and criteria for task definition are presented and discussed, and assumptions are made in order to better conceptualize functional tasks.

1.3 ORGANIZATION

Operations planning for this disposal action has been divided into four major areas as follows:

- Inventory of PCB waste stocks (Section 2)
- Land-based operations (Section 3)
- At-sea operations (Section 4)
- Logic network and schedule (Section 5)

Appendices are included to provide added detail to discussions in the text. They include a detailed inventory of PCB wastes (Appendix A) and a safety plan (Appendix B).

2. INVENTORY OF PCB WASTES

2.1 ORGANIZATIONS CONTACTED

The first step in compiling the inventory of PCB wastes was to define the list of government organizations to be contacted. This list consisted originally of four organizations, defined by EPA, from whom the Agency had received requests for disposal assistance. After initial contacts with these organizations, it was determined that the quantity of wastes was less than the minimum amount necessary to make at-sea incineration economically feasible. Therefore, the list of contacts was expanded at EPA's request to include other government and private industry sources. In all cases, Regional EPA offices were contacted for assistance in locating government-owned stocks of PCB wastes.

The individual in each organization responsible for PCB disposal was identified and asked specific questions regarding waste stocks under his jurisdiction. These questions related to the following:

- Waste volume and chemical composition information
  - Total volume and/or weight of liquid PCB wastes
  - Size, type, and condition of storage/shipping containers
  - Amount of waste in each container
  - Proportion of waste which is pumpable
  - PCB content and carrier for each waste
  - Volume of each "container type/fluid type/PCB content" combination
  - Information on waste compatibility
- Transportation information
  - Location of wastes in storage
  - Applicable transport modes (rail, truck, barge)
  - Suitability of storage and transportation facilities for handling toxic wastes
  - Applicable state and local transportation regulations (which may be more stringent than Federal regulations)
  - Special loading requirements
  - Incidents which have occurred in the past which might impact future transportation of PCB wastes

Information obtained was often general in nature because, for example, specific analyses had not been performed on the wastes.

2.2 QUANTITIES AND LOCATIONS OF WASTE STOCKS

Government-owned PCB wastes in the inventory were grouped as available and potentially available. Available stocks included those wastes which were (1) liquids incinerable on the Vulcanus; (2) currently stored and ready for transport and disposal; and (3) owned by an organization which expressed a positive interest in participating in an EPA-coordinated test burn, and which was willing to pay all disposal costs.* The type, quantity, and location of approximately 1.3 million gallons of PCBs under government ownership were identified. Of this total, only about 425,000 gallons were considered immediately available for at-sea incineration.

Potentially available stocks included wastes which were identified in the inventory but which did not meet all of the three above criteria. About 843,000 gallons of PCB wastes were identified as potentially available. They consisted primarily of PCB fluids in transformers, lubricating systems, and hydraulic systems which did not meet criterion 2. About 17% of the potentially available PCBs were not considered available because criterion 3 was not met. A cursory survey of several industrial sources indicated that an additional 836,000 gallons of PCB fluids were also available from those sources.

Figure 1 shows the volume percentage of available government-owned PCBs located in each state. Tennessee, with 51%, has the largest volume. Most of the available PCBs (about 85%) are located in the four states of Tennessee, Texas, Ohio, and Alabama. About 75% of the potentially available PCB stocks are located in the states of Ohio, Tennessee, and Kentucky.

2.3 DETAILED DESCRIPTION OF WASTE STOCKS

For the purposes of this inventory, available government-owned liquid PCB waste stocks have been divided into two categories as follows:

---

*Criterion 3 was slightly modified for the final inventory from an original criterion that a positive interest was expressed and only transportation costs would be paid by the waste owner. The change was made to ensure that stocks could be considered available, even if EPA could not reimburse each organization for the costs of waste processing and incineration. Such reimbursement had been assumed when compilation of the inventory began.

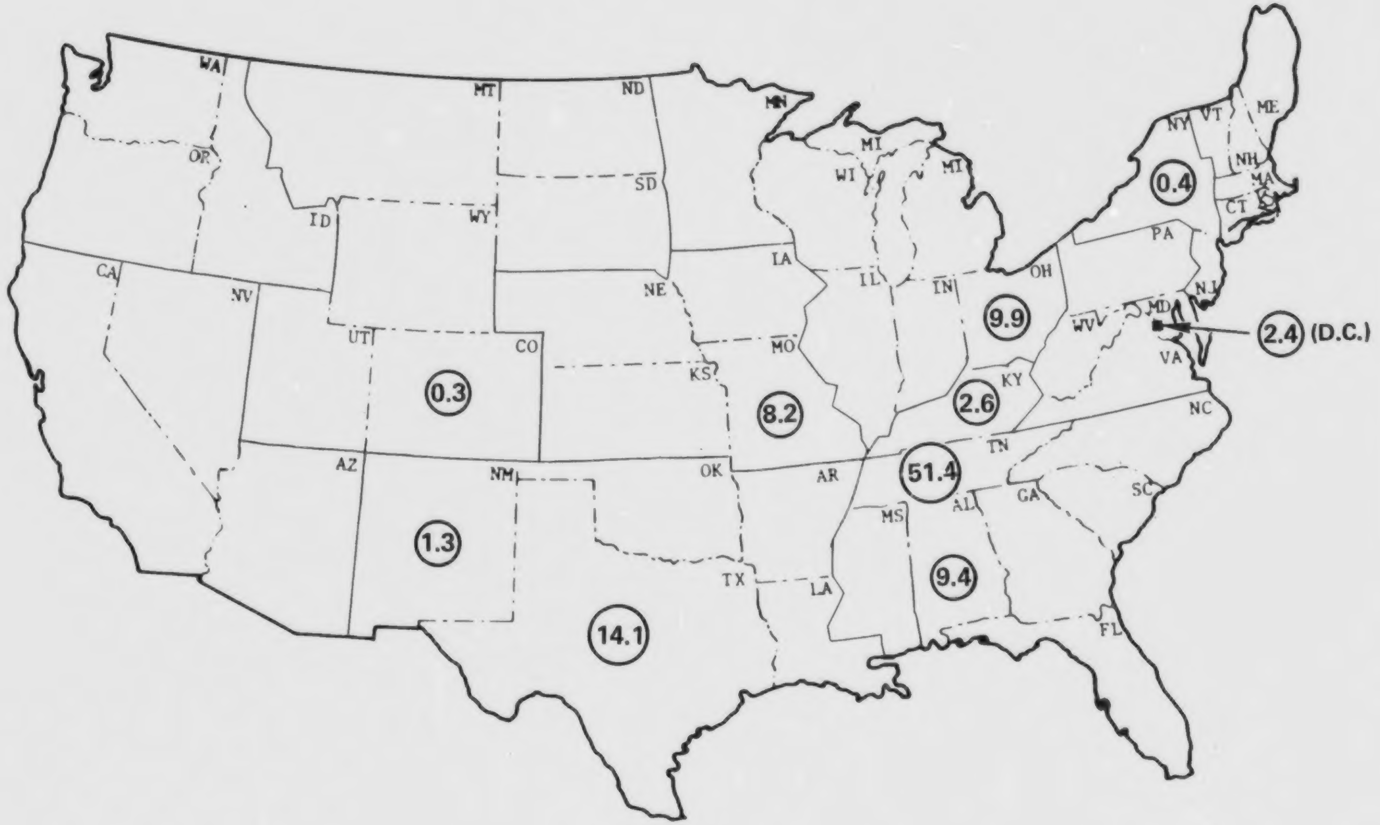

WA
MT
ND
MN
OR
ID
WY
SD
WI
MI
MI
NY
VT
ME
NH
MA
CT
0.4
PA
CA
NV
UT
CO
NE
IA
IL
IN
OH
9.9
NJ
MD
2.4 (D.C.)
WV
VA
0.3
KS
MO
8.2
KY
2.6
NC
AZ
NM
OK
AR
TN
51.4
SC
GA
AL
MS
1.3
TX
LA
9.4
14.1
FL

Figure 1. Percentage of Available PCB Wastes Located in Each State.

- Category A wastes consist of organic liquids with PCB content of 500 ppm or greater
- Category B wastes consist of organic liquids with PCB content less than 500 ppm

Table 1 summarizes information on ownership, volume, PCB content, and location of available PCB wastes. Several assumptions were made in compiling the data in this table in cases where information from owners was insufficient. If owners indicated that both transformer fluid and capacitor fluid was available, but did not know how much of each was present, equal volumes were assumed. For transformer fluid and capacitor fluid, PCB contents of 70% and 100% were assumed, based on information from Reference 1. This assumption probably overestimates the PCB content of transformer fluids, because many of these units (e.g., PCB-contaminated transformers) contain much less than 70% PCB. Another assumption was made regarding the specific gravity of PCB stocks owned by government organization #4. This organization reported quantities in pounds, and gave a range of estimated specific gravities. Estimation of the specific gravity for these stocks may have resulted in an error of ±20% in volume calculations.

Based on the data in Table 1, an average PCB content for stocks in each category (A and B) was calculated. This average, calculated as the volume-weighted sum of concentrations in Table 1, represents an estimate of what the concentration of Category A and Category B wastes would be if each were blended separately. Results of these calculations are presented in Table 2. The average PCB content of Category A wastes is 39% and of Category B wastes 70 ppm. The overall average PCB content of all waste, that is, the PCB concentration if all wastes were blended together, is 24%.

Approximately 121,000 gallons, or 30% of the available PCBs are stored in 55-gallon metal drums. The remaining 70% are stored in bulk. Processing requirements for drummed waste are detailed in Section 3.

Truck transport is applicable to all available PCB stocks, and rail transport is applicable to over 70% of all stocks (by volume).

Appendix A contains more detailed information on all aspects of the PCB inventory.

TABLE 1. GOVERNMENT-OWNED PCBS AVAILABLE FOR AT-SEA INCINERATION

Government Organization	Volume, gallons	PCB Category*	PCB Concentration†	Location
1	8,500	A	(70%)	Washington, DC area
1	1,500	B	(50 ppm)	Washington, DC area
2	20,000	A	(70%)	Alabama
2	1,500	A	(70%)	New York
3	20,000	A	(70%)	Alabama
4‡	42,300	A	(70%)	Ohio
4	11,200	A	(70%)	Kentucky
4	12,000	A	(70%)	Tennessee
4	20,000	A	2500 ppm	Tennessee
4	6,000	A	1000 ppm	Tennessee
4	8,000	A	700 ppm	Tennessee
4	10,600	A	(500 ppm)	Tennessee
4	160,000	B	70 ppm	Tennessee
4	2,000	B	(50 ppm)	Tennessee
5	35,000	A	40%	Missouri
5	5,500	A	(70%)	New Mexico
5	1,200	A	(70%)	Colorado
6	3,800	A	35%	Texas
6	56,200	A	500 ppm	Texas

*PCBs were categorized as follows: A = ≥500 ppm PCB (organic); B = <500 PCB (organic). These categories were based on the regulatory 500 ppm/50 ppm cutoffs and combustion considerations.

†Concentrations in parenthesis are TRW estimates based on the following: transformer fluid - 70% PCB; capacitor fluid - 100% PCB; rinsate - 50 ppm PCB. Otherwise concentrations are based on data obtained from waste owners. Proportions of transformer fluid, capacitor fluid, and rinsate are TRW estimates, unless data were available from owners. Rinsate volume is assumed to be 15% of the total volume, if present. Equal amounts of transformer and capacitor fluid are assumed, if both are present.

‡Estimation of specific gravities for these stocks may have resulted in ±20% error in volume calculations.

TABLE 2. SUMMARY OF GOVERNMENT-OWNED PCBs AVAILABLE BY CATEGORY

Category	Volume Available	Average PCB Content* (Estimate)
A (≥500 ppm PCB)	261,800 gal.	39%
B (<500 ppm PCB)	163,500 gal.	70 ppm
TOTAL	425,300 gal.	Overall avg = 24%

*Average PCB content for each waste category is obtained by taking a volume-weighted sum of the PCB concentration data in Table 1.

3. LAND-BASED OPERATIONS

Land-based operations in the PCB disposal action include collection, preparation, transport to a land-based processing facility, processing and interim storage, transport to ship loading site, and ship loading. The obkective of the land-based operations plan is to identify and plan in logical sequence all necessary activities prior to at-sea operations. This plan is developed in terms of the sequential flow of activities and decision points needed to carry out this phase of the disposal action in an effective manner with due consideration to constraints imposed for public safety and environmental protection.

Preliminary plans for collection and transportation of PCB wastes are based on the assumption that a land-based processing facility near a port on the Gulf of Mexico will be used. A Gulf Coast location was chosen mainly because it is close to available PCB stocks and an EPA-designated ocean incineration site.

3.1 COLLECTION AND PREPARATION OF PCB WASTES

PCB wastes to be disposed of by at-sea incineration must be collected and prepared for transport to the land-based processing facility. Currently all of the available PCBs are being stored in bulk or in 55-gallon metal drums. Preparation for transport of these wastes must be in accordance with prescribed procedures and regulatory requirements.

3.1.1 Legal and Administrative Requirements

The preparation, collection and transport of PCBs designated for destruction will involve certain legal and institutional policies and procedures which must be considered. The following sections describe the significant Federal, state and local rules and regulations governing PCB handling and transport which are applicable to this phase of the disposal operation.

3.1.1.1 Federal Rules and Regulations--

The U.S. Department of Transportation (DOT) is responsible for publishing and maintaining regulations controlling the transport of all hazardous materials within the U.S. These regulations apply to the surface and rail transport of PCBs. The regulations are under Title 49, Code of Federal Regulations (CFR). The pertinent parts are as follows:

Part 171	General information, regulations and definitions
Part 172	Hazardous materials table and communications regulations
Part 173	Shippers-general requirements for shipments and packagings
Part 174	Carriage by rail
Part 177	Carriage by public highway
Part 178	Shipping container specifications
Part 179	Specifications for tank cars

A hazardous material is defines in Title 49 as "any substance which has been determined to be capable of imposing an unreasonable risk to person or property." Title 49 also states that "no person may offer or accept a hazardous material for transport in commerce within the United States unless that material is properly classed, described, packaged, marked, labeled and in good condition for shipment."

Also, the regulations state that "it is the duty of each person who offers a hazardous material for transportation to instruct each of his officers, agents and employees having any responsibility for preparing hazardous materials for shipment as to the applicable regulations."

Proper shipping name--The hazard class of a hazardous material is the key to determining the "proper shipping name." The Hazardous Materials Table in 40 CFR 172.101 indicates that the hazard class for polychlorinated biphenyls is Other Regulated Materials-E (ORM-E). The proper shipping name is polychlorinated biphenyls (RQ-10/4.54).

Labeling/markings--Labeling procedures are not delineated per DOT regulations for PCBs. Some specific packaging requirements for ORM-E are indicated in Section 173.510. Regulations under the Toxic Substances Control Act (TSCA) address marking of PCBs and PCB Items (40 CFR Part 761.20 of the

PCB Regulations). Proper marking of the PCBs is described in part 761.44, Marking Formats.

Documentation (shipping papers)--Under DOT regulations, each shipment must be accompanied by the appropriate documents, with information entered in the exact format described in 49 CFR 172.200-204. For rail and surface this can be a single document describing the hazardous material by name, hazard, labels and quantity. In addition, the shipping papers must include a statement verifying the contents, and that the shipment is in proper condition for transport.

Additional transport documentation is required under Resource Conservation and Recovery Act (RCRA) regulations 40 CFR Part 263 - Standard Applicable to Transporters of Hazardous Waste. Subpart B of this section describes the manifest system whereby a transporter may not accept hazardous waste from a generator unless it is accompanied by a manifest signed by the generator and in accordance with the provisions of 40 CFR Part 262. Although RCRA regulations do not apply directly to PCBs, it is recommended that a RCRA-type manifest system be employed.

Mode of Transport--There may be additional regulations or tariffs that pertain to mode of transportation. Each of these is based primarily on safety considerations as would apply to the particular mode of transport. Surface transport is covered under DOT regulations, 49 CFR 172.500. Other parts of the regulation which should be consulted are 177, Carriage by public highway. Regulations pertaining to carriage by rail are covered under Part 174, Carriage by rail, and Part 179, Specifications for tank cars.

Temporary Storage--A critical safety factor is proper storage prior to, during and after shipment. Materials of the same hazard class should be stored together, provided they can employ the same retardants in case of incident. Additional requirements may be necessary. Temporary storage is also addressed in the PCB Regulations (40 CFR 761).

Incident Reporting--Title 49, 171.15-16 requires each carrier transporting hazardous material to complete a transportation incident report (DOT Form F-5800-1) in the event of the following:

- Death
- Injury requiring hospitalization
- Carrier damage exceeding $5,000 (or property damage of $50,000)
- Fire, breakage, spillage or suspected radioactive contamination
- A situation that the carrier believes should be reported.

Spill Reporting--DOT regulations (40 CFR 177, Subpart D) address accidents involving vehicles and shipments in transit. Spill reporting procedures for PCBs are also addressed in the PCB Regulations (40 CFR Part 761). Emergency procedures have been addressed in this report under Section 3.2.7. Additional spill reporting and emergency procedures may apply, such as provisions of the National or Regional Contingency Plans.

Safety Requirements--Additional safety procedures may be required in pertinent federal rules and regulations. It is the sole responsibility of the waste owner and his designated carrier to be aware of and follow all rules and regulations required for the safe transport of PCB wastes to the processing facility. Recommended safety procedures over and above regulatory requirements are described elsewhere in Section 3.

3.1.1.2 State and Local Rules and Regulations--

EPA Regional Offices should be aware of State regulations concerning the preparation and transport of PCB wastes. If a Regional Office does not have this information, then the State agency responsible for regulating transport in and through the state should be contacted. Also, State agencies may be able to assist with local agency coordination.

It is the responsibility of the waste generator to comply with state and local rules and regulations concerning the transport of his PCB wastes to the processing facility. States will have to comply with federal rules and regulations governing hazardous waste transport. In some cases, the state or local authorities will have enacted legislation or regulations more stringent than or in addition to the federal requirements. For example, Alabama requires all hazardous material carriers to register with the Public Service Commission. The Alabama Health Department requires the issuance of a hazardous waste manifest. The state of Missouri requires that all hazardous material transporters be licensed by the Department of Natural Resources. This department also requires a manifest. In Pennsylvania, the Pennsylvania Turnpike Commission requires all hazardous material transporters to be permitted. Other requirements may exist and these must be determined prior to shipment of the PCB wastes.

3.1.2 Waste Collection and Preparation Procedures

Upon notification of waste availability for incineration, detailed plans for collection, preparation and transport will be initiated. PCB wastes at each site should be sufficiently characterized to provide the experimental evidence needed to determine the type of waste (i.e., PCB content and carrier), net heating value, compatibility with other wastes, and any special safety precautions or decontamination procedures that may be required in the subsequent handling of the waste. Some wastes may need further characterization or filtration in preparation for shipment. Processing requirements and capabilities of the land-based facility may influence the degree of preparation necessary at the storage site.

A definitized handling sequence plan should be generated by each owner of PCB waste using the DOT and spill regulations, the location and physical conditions of the waste, waste category, and specific chemical analyses. Wastes in each category should be segregated and marked or shipped separately. The corrosiveness, volatility, flammability, and general toxicity should be used to determine if special containers for waste transfer are required. Similarly, any exposure/handling precautions should be identified.

An inspection should be made of all containers prior to loading with the waste. This inspection will verify that the approved type of containers are being used, that integrity requirements are met, and that proper seals, identity labels, and materials for containing spillage during loading are available.

The actual waste loading should be followed by an inspection for leaks and external contamination. Equipment used for transferring the waste to the containers that has come in contact with PCB should be decontaminated on-site.

Firm commitments for transfer of the approved waste containers should be obtained by the owners of the waste. This commitment should include methods of transport, schedules, waste code identifications, routes, destinations, liability, and authority transfer requirements. Written instructions should be provided for actions in case of spillage, fire, or need for in-transit transfer from one vehicle to another.

3.2 TRANSPORTATION TO PROCESSING FACILITY

PCB wastes will be transported to the land-based processing facility by the method chosen by the owner of the waste which is consistent with public safety, protection of the environment and the desires of the processing facility owner. Alternative transportation modes are a significant factor in the safe movement of the wastes from one location to another. Monitoring during transport will minimize public risk. A detailed contingency plan should be prepared and implemented for the selected transport mode.

3.2.1 Alternative Means of Transport

The transport modes considered for the movement of PCB wastes are truck and rail. Based on a survey of owners of available government-owned PCBs (Section 2), truck transport is applicable to all stocks, and rail transport is applicable to about 70% of all stocks (by volume).

There are several areas in which the two can be compared:

- Load Size. The train will carry the larger load.
- Material Transfers. Spills during transfer of hazardous materials from one container to another, from one part of a storage site to another, from one vehicle to another, or during vehicle loading and unloading operations are normally small. Truck transport would require the fewest material transfers. Regardless of mode selected, it is likely that significant amounts of trucking will be necessary.
- Material Storage. Depending upon the size of the load to be carried, hazardous material may have to be stored while enough accumulates for a full shipment. Trucks would require virtually no interim storage, while trains would certainly require some storage, during which time an incident could occur that might well be serious if storage were close to areas of environmental sensitivity.
- Accident Risk. Although it is generally concluded that the accident frequency for trucks is higher than for trains, the risk of a major spill by train is greater than by truck.

3.2.2 Ground Transport Shipping Methods

There are various ground vehicles in which the PCB wastes may be transported safely from one location to another. These may be categorized into bulk shipment and containerized shipment methods. Another consideration is whether dedicated or common carriers should be used.

3.2.2.1 Bulk Shipment--

Tank trucks, which have good access to PCB storage locations and low risk of spillage during transfer of liquid PCB from storage drums to tank truck, can be used. These trucks could make several stops to accumulate a full load (5,000-6,500 gallons), although the first stop should provide at least 1,000 gallons to ensure sufficient stability for the partially filled truck. Specialized tank trucks would not have low-level valves, and they could include vacuum suction and discharge units, a sludge pump, special internal lining, insultation, placarding, etc.

Railway tank cars would hold 10,000-11,000 gallons and in most instances would require transfer of liquids to them by truck. They would sometimes require storage of liquids temporarily while awaiting arrival of a freight train. Specially outfitted tank cars for carrying hazardous materials are also available.

Piggyback transport of liquids would involve placing the trailers of tank trucks directly on railroad flat-cars for transport to the disposal site. This combination would minimize material transfers, handling, and storage prior to rail shipment and decrease the likelihood of hazardous spills during transport.

3.2.2.2 Containerized Shipment--

Containers of hazardous waste, carried on a flatbed truck would not normally be stacked, but should be arranged in such a way as to allow periodic inspection. The truck should be equipped to contain any liquid leakage on the bed of the truck. In case of an accident, a flatbed would allow greater dispersal of materials than would a van-type truck.

Containers shipped in a large van should not be stacked. Loading and unloading operations would provide a greater chance for a minor spill than if a flatbed were used since the van floor is normally higher off the ground. A van is also somewhat less stable than a flatbed due to its higher center of gravity. In case of an accident, knowledge of the concentration of spilled materials would be desirable.

3.2.2.2 Dedicated vs. Common Carriers--

The question of whether a dedicated or a common carrier be assigned all PCB transport is complex. The dedicated carrier normally specializes in the transport of specific materials and has drivers trained in the characteristics and handling of those materials. The common carrier may have long experience in the handling of bulk chemicals, has better availability of transport vehicles, and is generally able to carry higher levels of insurance due to its greater asset value, higher income, and broader scope of operations.

Because training in the characteristics of one hazardous substance may vary somewhat from that required for the care and handling of another substance, there is no guarantee that previous driver training would be entirely transferable. However, the dedicated carrier's specialization and past driver training could be expected to give some advantage over the common carrier with regard to protection of the public and the environment.

It is most important that whatever type of carrier is used, there should be someone in the transport vehicle who has been specially trained in the characteristics and handling of PCB and response to various PCB spills, unless:

- The transport vehicle is accompanied by an escort vehicle
- The shipment is small, i.e., no greater than ten drums or the equivalent

3.2.3 Monitoring During Transport

Visual monitoring will be employed during PCB waste loading, transport and unloading. All incidents of leakage will be handled as described in Section 3.2.5 (Contingency Planning).

Monitoring of tank trucks or tank cars during loading will be performed in compliance with DOT regulations, 49 CFR 173.31(b)1 and 174.8 through 174.10, respectively. Valving will be observed uncapped during filling to detect leakage; uncapped leakage through valving greater than a drip will preclude transport use until such leaks are repaired. Similarly, any leakage through rivets, seams, or couplings will preclude acceptance for transport use until appropriate repairs are performed.

Personnel should be designated for observation of tank trucks or tank cars during transport. Monitoring enroute could be performed from adjacent vehicles or vantage points or by periodically halting the transport vehicle for examination, as is appropriate.

3.2.4 Public Risk

The extent of public risk during bulk transportation of PCB waste to the land-based facility is largely dependent upon the mode of transport selected and the proximity of the waste generation facility to the processing facility. At some point in the transport of the PCB wastes from the generator to the processing facility transport in a truck will likely be necessary. It is also likely that these trucks will need to use public roadways.

In the event that transport on or near public thoroughfares is required the extent of public risk will be dependent upon the traffic and routing. Risks would be minimized by transport through areas of lowest habitation. Although public risk during transport is difficult to assess it can be minimized by proper routing and appropriate monitoring and contingency planning.

3.2.5 Contingency Planning

Prevention of spills of hazardous materials is far superior to cleanup. The transporter of the PCB wastes should have a spill contingency plan identifying procedures for containment, cleanup, and disposal of spilled materials, as well as manpower, equipment, and material resources to be committed in the event of a hazardous material spill. Documentation must be kept concerning the cause and location of the spill, estimated volume spilled, bodies of water threatened, response action taken, any further action proposed, and measures taken to avoid similar future spills.

3.2.6 Preparedness and Prevention

Preparedness and prevention, as they apply to bulk transport operations, should include leak checks of all transport equipment, maintenance of replacement equipment, provision for emergency containment and cleanup equipment, and notification of local agencies prior to initiation of transport operations. Although transport may be by rail tank car or tank truck, the approach employed will be similar regardless of the selected mode.

Transport equipment should be leak checked prior to initiation of transport operations. Tank cars and tank trucks should be pressure tested before use. Additionally, valving will be observed uncapped during filling to detect leakage. Leakage through uncapped valving greater than a drip will preclude transport use until such leaks are repaired. Leakage through rivets, seams, or couplings will preclude acceptance for transport use until appropriate repairs have been performed. Pipeline integrity should be verified consistent with American Society of Mechanical Engineers and DOT requirements.

Small leaks detected during operations should be contained in buckets or drums until all contents can be safely pumped to an alternate transport vehicle or a holding tank. Large leaks should be contained in diked areas lined with fiberglass reinforced plastic until safe transfer can be performed. The filling of any leaking equipment should be immediately terminated and its contents be transferred to an alternate unit.

Vapor pollution can be controlled be minimizing open handling of PCB wastes and equipping all transport equipment vents with activated carbon adsorbers. Open handling of PCBs should be limited to drip containment during coupling and uncoupling operations and leak or spill containment.

Bags of absorbent materials and emergency equipment such as shovels, brooms, squeegees, pails, sandbags, and sheeting of fiberglass reinforced plastic should be available in transport or accompanying vehicles for use in emergency spill containment.

3.2.7 Emergency Procedures

During transportation of PCBs and PCB-contaminated materials to disposal facilities, accidental spillage or leakage can occur. To control surface transportation of hazardous materials, the Department of Transportation published 49 CFR 170-178. All the regulations are designed to prevent spills from occurring and to protect life and property. An EPA document entitled "Manual for the Control of Hazardous Materials Spills: Volume 1 - Spill

Assessment and Water Treatment Techniques" lists information regarding all the activities that are necessary. Spill prevention procedures have also been listed in the PCB Regulations (40 CFR 761).

If spills do occur and a good faith attempt is not made to clean up the spill, then this constitutes improper disposal of PCBs and is a violation of the Toxic Substances Control Act and PCB Regulations. Violations may result in civil and criminal penalties. Federal regulations require that non-liquid PCB-contaminated materials such as rags and sorbent materials (e.g., sawdust or imbiber beads that have been used to absorb spilled fluids) be packed in drums before shipment to appropriate disposal sites. Liquid wastes including cleanup solvents such as kerosene and fuel oil must be packed in steel drums of appropriate wall thickness and then must be put into secured storage areas until disposal can be arranged. It is recommended that protective clothing be used by the personnel during the cleanup operation.

It is advisable that cleanup personnel use some kind of self-contained breathing apparatus because PCB fumes can be easily inhaled during this process. A comprehensive inventory of other protective clothing appropriate for spill cleanup is available in the U.S. Government Printing Office publication "A Survey of Personnel Protective Equipment and Respiratory Apparatus for Use by Coast Guard Personnel in Response to Discharge of Hazardous Chemicals".

3.3 CRITERIA FOR SELECTING PROCESSING FACILITY LOCATIONS

Major considerations in the selection of a potential site (or sites) for the processing and storage of polychlorinated biphenyls are public safety and protection of the environment. The site should meet the general criteria listed below. It should be:

- Close to available PCB waste stocks
- Close to the designated ocean incineration site
- Close to suitable port facilities
- Located in a sparsely populated area (it could be located in an industrial area)
- Secure, fenced, and have gates which provide controlled, limited access
- Neither in a fault area nor in a 100-year flood plain (this is a requirement under RCRA regulations)

- Located so as to minimize transportation time and distance to the ship loading dock and the at-sea incineration site
- In compliance with all pertinent Federal, state and local regulations
- Downwind of the nearest populated area

Due mainly to the first two listed considerations, the major site options for the location of the PCB waste processing facility were on the Gulf of Mexico or the mid-Atlantic Coast. A Gulf Coast location was chosen for the following reasons:

- The Gulf Ocean Incineration Site has been officially designated, whereas the Atlantic Ocean Incineration Site has not.
- A large proportion of the available PCBs are located in relatively close proximity to the Gulf Coast.
- The option of having the Vulcanus make a stop at both a mid-Atlantic Coast and Gulf Coast port was rejected because it did not appear logistically or economically feasible and would have posed no fewer problems from the standpoint of environmental harm or public safety.
- There are a number of ports in the Gulf Coast area capable of handling hazardous materials.

Suitable port facilities on the Gulf Coast include, for example, Houston, Texas and Mobile, Alabama. The land-based processing facility could be located in or near these ports.

3.4 PROCESSING OF WASTES AND CONTAINERS

Liquid PCB wastes slated for disposal by at-sea incineration must first be removed from their shipping containers and processed for disposal. Waste processing will include segregation of liquid PCBs according to the PCB concentration and the type of solvent present in the waste, removal of waste from the shipping containers, decontamination of containers, and preparation of containers for disposal. The most convenient facility for these operations would be a waterfront processing facility consisting of storage tanks, waste processing and handling equipment, a laboratory for waste analysis, and a cargo transfer terminal. However, inland processing facilities would also be suitable.

3.4.1 Processing Facility

The purposes of the processing facility are the following:

- To receive liquid PCB wastes;
- To analyze, blend, and containerize the materials as appropriate for incineration at sea;
- To load the waste aboard ship in a safe and efficient manner.

The ideal site for the facility would be located where potential environmental impact is minimal, transportation time from the storage site and to the ship loading dock minimal, and topography is convenient. Structural standards must be carefully followed, and these are normally defined by the Uniform Building Code and additional location-specific building regulations.

The design must also meet safety, health, and environmental criteria, which include provisions for facility monitoring, personnel safety, and contingency planning in the event of both major or minor releases of chemical wastes that have the potential to reach soil, water, or air. In general, these criteria are specified by federal regulations.

Federal regulations under RCRA require the owner/operator of a land-based facility handling hazardous wastes which supports an at-sea incineration vessel to obtain a permit. The facility chosen to support the Vulcanus should either:

- Have RCRA interim status, i.e., comply with the filing requirements of 40 CFR 122.22 and meet the applicable standards set forth in 40 CFR 265, or
- Have a RCRA permit and meet the applicable standards set forth in 40 CFR 264, or
- Have interim status or a final permit under an authorized state RCRA hazardous waste program.

The processing facility must be designed to prevent emissions of hazardous materials, contain spills, leaks and other accidents, and minimize harm to personnel in the event of accidents. Planned measures might include the following:

- Collection and disposal systems for vapors from waste transfer
- Detailed material balance audits
- Dry break valves which prevent spillage during disconnecting
- Above-ground plumbing and convenient access to fittings
- Use of corrosion resistant materials

- Pipes sloped away from points of potential discharge
- Complete fire prevention and control systems
- Security provisions including guards and continuous fencing around facility
- Special training in hazardous wastes for personnel
- Effluent and media monitoring in and around facility
- Dikes around liquid storage areas

A preliminary design for a waterfront waste processing facility has been developed and described in a Report of the Interagency Ad Hoc Work Group for the Chemical Waste Incinerator Ship Program (9). The general features of this design will be applicable to the land-based processing facility selected for processing PCB liquids.

3.4.2 Dedrumming Operations

Some of the PCBs to be disposed of by at-sea incineration will arrive at the processing facility in 55-gallon metal drums from which they must be removed prior to incineration. Overall dedrumming operations will include draining the PCBs and rinsing the drums to render them safe for disposal.

Upon receipt at the processing facility, drums will be visually inspected for damage and to insure that the contents are as indicated on the shipping papers. There will be a preliminary segregation of wastes into two categories:

A = $\geq$500 ppm PCBs in organic solvent
B = $<$500 ppm PCBs in organic solvent

3.4.2.1 Applicable Regulations--

Annex III of the PCB Regulations, 40 CFR 761.42, specifies that no item of movable equipment used for handling PCBs and PCB Items in the storage facilities that comes in direct contact with PCBs shall be removed from the storage facility area unless it has been decontaminated as specified in Annex IV, Section 761.43. Annex IV requires that any PCB Container be decontaminated by flushing the internal surfaces of the container three times with a solvent containing less than 50 ppm PCB. The solubility of PCBs in the solvent must be 5% or more by weight. Each rinse shall use a volume of the normal diluent equal to approximately 10% of the PCB container capacity. The solvent may be reused for decontamination until it contains 50 ppm PCB.

Empty drums must be disposed of in accordance with provisions of Section 761.10 of the PCB Regulations. Annex II (Section 761.41) specifies the location, design, and operating requirements for chemical waste landfills suitable for disposal of PCBs and PCB Items.

3.4.2.2 Drum Handling--

A system developed to empty and rinse drums containing hazardous liquids was used and evaluated in the case of dedrumming Herbicide Orange prior to its thermal destruction onboard the M/T Vulcanus in 1977 (10). This system, which is described below, may be adapted for dedrumming liquid PCB wastes.

The 1.5 million gallons of Orange Herbicide stored on Johnston Island represented approximately 25,000 drums of 55-gallon capacity. These were stored in rows stacked three high in an area of about 3.5 acres on the northwest corner of the island. A dedrum facility was modified* to allow transfer of the material from drums to bulk carriers or pipeline for transport to the ship. The facility and operation basically consisted of a covered concrete pad and two fabricated metal racks upon which full drums were placed in four groups of 12 each. Drums were transported from the drum yard in sets of four using fork lifts equipped with specially designed clamps. Each set of 12 drums was handled independently by the dedrumming crew. Once the drums were on the rack and the fork lift had withdrawn, a crew member would punch one hole near the top of each drum to allow the crew's supervisory personnel to check the contents of the drum for Orange Herbicide. Any suspicious drums were removed from the line and held for further testing prior to loading. Three closely spaced holes were then punched in the bottom of each drum and the fluid allowed to drain. A set drain period of 5 minutes was determined prior to testing to give the most rapid throughput of drums and still achieve good drainage.

---

* The facility had originally been installed for redrumming of leaking drums.

Following the 5-minute drain, the inside of each of the drums was rinsed with 1 gallon of diesel fuel using a spray wand. Operators were instructed on the proper technique for covering the entire drum interior. After draining for 2 minutes, a second one-gallon spray rinse was initiated and 2 minutes were allowed for draining herbicide and rinse into a trough which flowed into a sump equipped with pumps to transfer the material to a tank truck. Studies on the rinsing efficiency of Herbicide Orange from the drums showed that the first and second rinses yielded the same efficiency of approximately 68 percent removal each (total of 90% removal vs. 85% triple rinse).

It is essential for operation of the processing facility that the contents and level of PCBs in the drums is known prior to dedrumming. Testing should be done prior to processing to determine the concentration of PCBs in cases where this unknown. The two waste types - PCB transformer and capacitor fluids (PCB concentration $\geq$500 ppm), and PCB-contaminated mineral oil and other organic liquids (PCB concentration 50-500 ppm) - should be processed and stored separately. Each type of waste should be stored and processed with other wastes of the same type upon receipt at the facility and throughout processing, interim storage, and ship loading.

Rinsate from drum decontamination which contains less than 50 ppm PCB, should be stored in a tank separate from the PCB liquid wastes and reused for additional rinsing. Rinsate that becomes contaminated with more than 50 ppm PCB could be blended with type B wastes. Appropriate solvents for rinsing include kerosene, xylene, toluene or other solvents in which PCBs are readily soluble. The number of rinses required and the quantity of solvent to be used per rinse are specified in Annex IV of the PCB regulations and were discussed in Section 3.4.2.1. Since a volume equal to 10% of the container capacity is required for each of the three required rinses, the quantity of solvent needed will range from 10 to 30% of the container capacity depending on how often it can be reused before reaching a concentration of 50 ppm PCB. Alternate procedures for rinsing may be used if they can be shown to be equivalent to a triple rinse.

PCBs arriving in tank cars or trucks should also be tested before pumping to the appropriate storage tank if the contents are unknown. The tank cars will be decontaminated as specified in Annex IV. The rinsate solvent will be reused until it contains 50 ppm PCB.

3.4.2.3 Vapor Disposal--

Control and disposal of vapors released during PCB dedrumming is essential for protection of personnel and the environment. Under the provisions of 29 CFR 1910,1, the Occupational Safety and Health Administration (OSHA) TWA* (air) for Aroclor 1242 is 1 mg/m^3 and the TWA (air) for Aroclor 1254 is 0.5 mg/m^3. In September 1977, the National Institute for Occupational Safety and Health (NIOSH) recommended a time-weighted average for all PCBs of 1.0 μg/m^3 (18). However, this is a recommendation and is not legally binding. The OSHA standard has not yet been changed. The current threshold limit value (TLV) for PCBs as established by the American Conference of Governmental Industrial Hygienists (ACGIH) is 0.5 mg/m^3.

The solvent kerosene, which may be used in drum rinsing, is sufficiently volatile that the maximum allowable time weighted average concentration of 15 ppmv may be exceeded in an enclosed structure if vapors are not controlled. The preferred method for disposing of vapors from the dedrumming operation is by incineration. Facility air exhaust could be piped directly to an on-site incinerator as part of combustion air feed. A second method of vapor control is venting through activated charcoal absorbers before reaching the atmosphere. This procedure was utilized during Herbicide Orange dedrumming operations at Gulfport, Mississippi. Negative pressure maintained within an enclosed dedrumming facility by the ventilation system would minimize fugitive emissions.

3.4.2.4 Facility Monitoring--

Monitoring of the processing facility: 1) aids in the detection of spills and leaks or vapor buildup from equipment malfunction; 2) ensures adequate industrial hygiene; and 3) provides a measure of environmental impact concurrent with facility operations. Hence, multimedia monitoring should be an integral part of the dedrumming operation. A basic approach to air quality monitoring for chlorinated hydrocarbons has been discussed in the operations plan for at-sea incineration of liquid silvex (11) and is anticipated to be applicable to liquid PCB wastes. Basically, this consists of collecting samples in an absorption tube filled with a solid polymeric adsorption medium. An alternative is the use of continuous hydrocarbon monitors such as flame ionization detectors.

---

* TWA = Time-Weighted Average, the concentration to which a worker can be exposed for 8-hour days and 40-hour weeks indefinitely without adverse effects.

3.4.2.5 Water, Soil, and Sediment Monitoring--

Water quality monitoring should be concentrated on fresh water drainages in close proximity to the processing facility and on any effluents from the facility. All process water outfalls whether originating from direct equipment contact (i.e., pump seal flush water, cleanup water, etc.) or secondary contact facilities (i.e., laundry facility effluents) should be included. Composite samplers should be utilized where appropriate and aliquots collected daily for analysis. In addition to analysis for PCBs, analyses for dissolved oxygen, temperature, and pH should be determined daily. Water quality monitoring should commence about three days prior to facility operations and continue for about three days following facility shutdown.

Sediment samples should be obtained at all locations selected for water quality monitoring during pre- and post-operational monitoring. Additional sediment samples may be obtained during dedrumming operations as indicated by water quality monitors.

Soil samples should be collected from areas subject to the highest concentrations of PCBs. At a minimum, soil samples should be collected from locations downwind of the processing facility, directly adjacent to the processing facility, at any PCB transfer or storage areas for which concrete pads are not provided, and in the vicinity of any known spills. Soil samples should be obtained during pre- and post-operational monitoring. Additional soil samples may be obtained during dedrumming operations based upon indications from operations, air, or water quality data.

3.4.2.6 Drum Disposal--

Drums will be rendered suitable for disposal following decontamination. Handling of drums for disposal could be expedited by crushing prior to transport to the disposal site. Spray shields should be used around the crusher to trap any residual oils or solvents which are released on impact. Crushed drums should be bundled and stored for disposal in such a manner that there is no danger of rainwater washing any residuals into the surrounding environment. Drums could be scrapped, recycled, or disposed of in landfills that meet the criteria set forth in Annex II of the PCB Regulations.

3.4.2.7 Personnel Safety--

Maintenance of personnel safety requires implementation of an effective personnel hygiene program and appropriate safety procedures. Workers may be exposed to PCBs as a consequence of equipment malfunction or breakdown, leaks, spills, and various accidents.

There are three routes by which a toxic agent can enter the body: ingestion, inhalation and skin absorption. Ingestion or swallowing of industrial products is sometimes encountered when workers eat or smoke without washing or when foods or cigarettes are stored near where toxic materials are used. Skin absorption is a more insidious or hazardous route of entry into the body than ingestion because it is not easily noticeable. It generally occurs during transfer and handling of products or chemicals. Inhalation is a more general hazard than ingestion or skin absorption because no visible physical contact between the worker and the compound is required. Airborne particulates, gases, and vapors not only contaminate the work space, but due to transportation by air. currents also contaminate the surrounding areas.

It is difficult to differentiate between industrial exposure by inhalation and dermal absorption. Animal studies do indicate that animals exposed to PCB aerosols show rapid increases in liver PCB levels. Airborne exposure to Pyranol A200 for 15 minutes was reported to have resulted in the accumulation in the liver of 50 percent of the PCBs accumulated after two hours (12). The lung appears to be a good site of absorption, and certain occupational environments contain significant levels of airborne PCBs. The National Institute of Occupational Safety and Health has recently proposed an occupational exposure limit of 1.0 $\mu g/m^3$ on a time weighted average 10-hour day, 40-hour week basis (Natl. Inst. Occup. Safety Health, 1977). Assuming a tidal air volume of 10 m^3 in an eight hour day and 100 percent absorption, the resulting dose at this exposure level would be 10 μg/day.

The comprehensive health and safety plan developed for protection of shipboard personnel during the incineration of Herbicide Orange (13) can be adapted for use in the PCB processing facility. The safety plan is discussed in detail in Appendix B. The concept of isolation of contaminated areas and preservation of "clean" areas should be utilized during dedrumming operations. An interface area should be maintained which will ensure the integrity of the clean area and the safety of personnel therein while isolating contaminated areas. Adherence to this concept will prevent PCB contamination of facilities suitable for eating, drinking, smoking, and final clothing changes prior to departure from the facility. The routes by which personnel move should be arranged so that the entrance to the working area and exits from the working area are separate, thereby preventing possible confusion and subsequent contamination of clean changing facilities.

Basic requirements for effective personnel hygiene during dedrumming operations are:

- Protection of personnel from vapor and liquid contact in the contaminated areas by source control and protective gear.
- Provision for contaminated clothing collection facilities at the interface region between the contaminated and clean areas.
- Provision for shower, hand, face, and eye-washing facilities at the interface region.
- Provision for clean work clothing and footwear at the boundary of the interface region between the contaminated and clean areas.
- Instruction in the use of cleaning equipment and protective equipment and in the methods of personal cleansing.
- Mandatory and enforced use of the above facilities and concepts.

Equipment utilized during the Herbicide Orange decanning operations and which are applicable to PCB dedrumming operations are as follows:

- Clean or disposable coveralls which should be provided prior to admission to the work area.
- Impervious footwear which should be provided prior to admission to the work area and worn at all times therein.
- NIOSH approved gas respirators which should be worn at all times when working in the vicinity of open PCBs or other areas of potentially high vapor concentrations.

- Rubberized splash aprons which should be worn when working in the vicinity of open PCBs.
- Rubber gloves which should be worn when handling PCB drums or equipment subject to direct PCB contact.
- Face shields which should be worn when working with any dedrumming or transfer equipment requiring open handling of PCBs or the uncoupling of equipment which has been in direct contact with PCBs.
- Safety goggles which should be worn in the vicinity of any PCB dedrumming or transfer equipment which is in service.

Designation of specific safety equipment for use during PCB dedrumming operations will be made by health and safety representatives of the selected facility contractor(s). Considerations influencing equipment selection include facility design and the efficiency, comfort, and ease of operations of safety equipment. All personnel working in contaminated areas should be given complete pre- and post-operational medical examinations.

3.4.2.8 Spill Prevention and Control--

Prevention of spills of hazardous materials is far superior to cleanup. An established safety procedure is mandatory under the Clean Water Act for safe spill control and prevention. A spill coordinator should be assigned for each PCB processing facility. He should be thoroughly familiar with established safety and reporting procedures. All other personnel likely to be confronted with a PCB spill should also be aware of the proper reporting procedures prior to any actual spill.

Reportable quantities for substances designated as hazardous under Section 311(b)(2)(A) of the Clean Water Act and requirements for notification in the event of such discharges have been established by EPA [40 CFR Part 117]. The regulation applies to quantities greater than or equal to the reportable quantity when discharged into or upon navigable waters of the United States, adjoining shorelines, into or upon the contiguous zone or beyond the contiguous zone. The reportable quantity for polychlorinated biphenyls has been set at 10 pounds (4.54 kg) (20).

In addition to the requirements of National and Regional Contingency Plans, any State reporting requirements must also be met. U.S. Coast Guard Regulations require that spills of hazardous substances that may affect water sources should be reported to the National Spill Response Center. Appropriate methodology for the control of PCB spills and reporting procedures is addressed in the EPA documents, "Manual for the Control of Hazardous Material Spills," EPA-600/2-77-227 (14,22).

3.4.2.9 Public Risk--

The extent of public risk during dedrumming operations is limited to potential contamination due to vapor escape and spills or discharges which could contaminate adjacent aquifers. The approach to dedrumming liquid PCBs and maintenance of attendant industrial health and environmental monitoring programs described herein are modeled after some of the approaches and programs successfully utilized by the U.S. Air Force during the Herbicide Orange disposal program. Hence, public risk associated with dedrumming operations following the procedures presented above should be low.

3.4.2.10 Contingencies and Emergency Procedures--

Key elements of a contingency plan include preparedness, prevention, notification, and emergency procedures. Perhaps the most important factor in reducing risks during dedrumming as well as in all other phases of this disposal action, is proper training of involved personnel. Additionally, clear definition of responsibilities of all participating organizations and the preparation of and adherence to detailed operating procedures will lead to minimized risk to personnel and the environment. Personnel involved in dedrumming operations (and in all other program phases) will receive comprehensive briefings on operations and will have to demonstrate adequate understanding of detailed operating procedures. Of all program tasks, dedrumming operations pose the greatest risk of exposure of personnel to PCBs. Dry runs of dedrumming as a part of training should be required.

The entire dedrumming-storage facility will be surrounded by a trench or diking to effect spill containment in the event of failure of dedrumming or bulk storage equipment. Bags of absorbent material will be situated throughout the processing facility for use in the event of spills. Emergency equipment such as shovels, brooms, squeegees, pails, sandbags, and sheeting of fiberglass reinforced plastic will be prominently situated and available for use in containment of any spills. On-site personnel will be trained in the use of the emergency equipment prior to initiation of dedrumming operations.

In the event of an incident, rapid notification of the appropriate agencies and implementation of corrective measures are of utmost importance. A release of any quantity of PCBs that either reaches or has the potential of reaching soil, water, or air will be reported to the facility emergency coordinator by the first individual on the scene. Notification will be made by the fastest means of communication available. Minor spills, leaks, or other discharges of small quantities of PCBs will be handled at the discretion of the facility emergency coordinator.

All incidents must be carefully documented with respect to time, location, severity, cause, type of pollutant, etc. The recommended notification format is the U.S. Air Force Pollution Incident Notification Format, AFR 19-1, Items 1 through 12. Incidents which are judged major by the facility emergency coordinator additionally require immediate notification of the project director and the following:

- EPA Regional Administrator or his designee
- Emergency Response Division, Office of Hazardous Emergency Response, EPA, Washington, D.C. (duty hour operation)
- U.S. Coast Guard (USCG) National Response Center (NRC), Washington, D.C. (24-hour operation)
- Director, Center for Disease Control, U.S. Public Health Service, Atlanta, GA.

For incidents that occur during non-duty hours, the NRC will use a list of on-call personnel from the Emergency Response Division of EPA to implement notification.

Incidents which have the potential for reaching coastal waters are under U.S. Coast Guard jurisdiction. In those cases, initial spill notification will be made to the appropriate USCG District Headquarters. Previously listed notifications will be made immediately following Coast Guard notification.

In the event that notifying personnel are unable to contact an above-listed agency, the next listed agency will be contacted immediately. Following initial completion of the above scheme, contacting personnel will again attempt to contact any missed agencies. This procedure will continue until all agencies have been contacted.

Detailed emergency procedures should be prepared consistent with the selected processing operations and facility. Spend absorbent and contaminated sheeting and sandbags should be placed in separate storage drums, properly marked, and stored for future disposal. Decontamination, subsequent to containment, should include clearly marking affected land areas for penetration tests. Upon determining the extent of penetration, affected soil should be removed, placed in empty drums, properly marked, and stored for future disposal. To the extent that it is feasible, contaminated waters should be collected for subsequent disposal.

3.5 INTERIM STORAGE OF BULK LIQUIDS

Any interim storage of dedrummed PCB liquids should be in tanks at the processing facility. OSHA has prepared comprehensive tank specifications [29 CFR Part 1910.106] based on standards developed by the American Society of Mechanical Engineers and the American Petroleum Institute. With liquids which have a specific gravity greater than 1.0, such as some PCB fluids, precautions must be taken to insure that an adequate factor of safety exists when evaluating the structural strength of the tanks due to the heavier stress put upon tanks by liquids with higher specific gravities.

The PCB Regulations contain specific requirements for temporary storage of PCBs and PCB Items which are designated for disposal. These are outlined in Annex III, Section 761.42.

Facilities for the storage of PCBs and PCB Items designated for disposal must, at a minimum, meet the following criteria [40 CFR 761.42(b)(1)]:

- Adequate roof and walls to prevent rain water from reaching the stored PCBs and PCB Items;
- An adequate floor which has continuous curbing with a minimum six inch high curb. The floor and curbing must provide a containment volume equal to at least two times the internal volume of the largest PCB Article or PCB Container stored therein or 25 percent of the total internal volume of all PCB Articles or PCB Containers stored therein, whichever is greater;

- No drain valves, floor drains, expansion joints, sewer lines, or other openings that would permit liquids to flow from the curbed area;
- Floors and curbing constructed of continuous smooth and impervious materials, such as Portland cement contrete or steel, to prevent or minimize penetration of PCBs; and
- Not located at a site that is below the 100-year flood water elevation.

In addition to the 761.42(b)(1) criteria, the following guidelines should be considered in evaluating the storage facilities:

- Storage capacity should be adequate to accept all incoming waste shipments and should slightly exceed the maximum desired inventory.
- Incompatible corrosive or reactive wastes should be segregated in the storage area.
- Materials used in construction of storage tanks for PCBs should be compatible with the physical and chemical form of the waste contained.
- PCBs should not be stored in an unwashed tank which previously contained incompatible materials.
- If underground storage tanks are used, provisions for gaging, pumping, and leak detection should be such as to minimize the possibility of a PCB release. Above-ground storage is preferred.
- Provisions for drainage of diked areas should assure that uncontrolled discharge to storm drains or surface waters does not occur. This may necessitate pumping stormwater drainage to an on-site pond or treatment system and pumping spilled wastes to alternate storage tanks.
- Spill cleanup equipment and supplies should be available to contain spills.
- Personnel safety equipment and procedures should be used as needed.

Temporary storage in an area that does not meet the 761.42(b)(1) criteria is allowed for up to thirty days in some cases, provided the date of removal from service is attached to the PCB Item or PCB Container. Temporary storage is allowed for PCB Containers containing non-liquid PCBs such as contaminated soil, rags, and debris; and for PCB Containers containing liquid PCBs at a concentration between 50 and 500 ppm, provided a Spill Prevantion, Control and Countermeasure Plan has been prepared for the temporary storage area in accordance with 40 CFR 112. In addition, each container must bear a notation that indicates that the liquids in the drum do not exceed 500 ppm PCB. Temporary storage is not allowed for high concentration PCB liquids (≥500 ppm).

3.6 TRANSPORTATION TO THE SHIP LOADING SITE

The anticipated location for the ship loading site is on the Gulf Coast. Based on a preliminary survey of terminal facilities capable of serving an at-sea incineration ship (21), adequate facilities are available at Houston, Texas and Mobile, Alabama to handle liquid PCB wastes.

Liquid PCBs and rinsate from the dedrumming and cleaning operations will be transported to the ship loading site by the available method considered to be most consistent with public safety and protection of the environment. Alternative transportation modes are a significant factor in selecting both the dedrumming facility and ship loading sites. Monitoring during transport will minimize public risk. A detailed contingency plan should be prepared and implemented for the transportation mode selected.

3.6.1 Administrative and Legal Constraints

Transportation of hazardous material is regulated by the U.S. Environmental Protection Agency under RCRA regulations, 40 CFR 250.22 to 250.24. These standards are coordinated closely with and incorporate by reference applicable U.S. Department of Transportation regulations for identification and transporting of hazardous materials, 49 CFR Parts 171-173 and 179.

3.6.2 Criteria for Selecting Loading Sites

Existing port facilities will be utilized for loading of PCBs onboard the incinerator ship. Site selection criteria include:

- Adequacy of port facilities for safe harboring and loading of the incinerator vessel.
- Minimizing transportation time and distance from the processing facility.
- Minimizing transport time to and from the selected incineration site.

Controlled access to the ship loading dock must be maintained from the start of loading operations until ship departure from port. Required port facilities include emergency equipment and personnel. Loading and spill control operations onboard the ship will be performed by the ship's crew under procedures discussed in Section 3.7.2. Land-based loading and spill control operations will be performed by personnel from the processing facility as discussed in Section 3.7.2. Monitoring of ship loading will be conducted as described in Section 3.7.4.

3.6.3 Transportation Modes

Alternative means of transporting the PCB waste from the processing facility to the ship loading site are by pipeline, rail tank car, and tank truck. All of these options may not be available at the selected dedrumming and docking sites.

A direct pipeline for transporting hazardous liquids from the dedrumming site to the loading dock will present minimal public risk. However, this mode would be economically feasible only if an existing pipeline is available between the port and a suitable processing facility. Decontamination of the pipeline by rinsing will be required after all of the PCB liquids have been transferred to the ship.

PCB liquids should be transferred to the ship in decreasing order of concentration, the most concentrated wastes being pumped first, to minimize the quantity of rinsate required as much as possible. Pipeline rinsate can also be loaded onboard ship for incineration.

Rail tank cars are the next choice for transporting bulk PCBs. This mode was utilized for Herbicide Orange transfer from the drum handling facility at Gulfport, Mississippi to the ship loading dock (15,16). Cars were moved the short distance to the dock at a low speed (about 5 km per hour) with guards at all rail crossings and absorbent materials present nearby to contain potential spills. Current DOT regulations (49 CFR 179) limit rail tank cars to 130 m^3 in volume. Tank trucks may also be used, preferably by private roadways. Use of public roadways presents the risk of accidents and potential spills.

Tank cars or tank trucks can be decontaminated effectively by employing a triple rinse approach and spraying the interior of holding vessels with the rinse liquid. Details of the decontamination procedures will be consistent with the recommended procedures for decontamination of PCB Containers, 40 CFR 761.43. Because the rinsing solvent may be reused for decontamination until it contains 50 ppm PCB, rinsing the tank cars/trucks which contained low concentration wastes first may allow the solvent to be reused to a greater extent, thereby decreasing the total quantity of solvent needed.

3.6.4 Monitoring During Transport

Visual monitoring will be employed during PCB loading, transport, and unloading. In the event of pipeline transport, seams, rivets, and fittings will be periodically examined for signs of leakage. All incidents of leakage will be handled as described in the contingency plan, Section 3.7.6.

Monitoring of tank trucks or tank cars during loading will be performed in compliance with DOT regulations, 49 CFR 173.31(b)(1) and 174.8 through 174.10, respectively. Valves, rivets, seams, and couplings will be observed during filling to detect leakage. Any leakage will preclude acceptance for transport use until repairs are performed.

Personnel should be designated for observation of tank trucks or tank cars during transport. Monitoring en route can be performed from adjacent vehicles or vantage points or by periodically halting the transport vehicle for examination, as is appropriate.

Air quality monitoring should be performed in the vicinity of loading and unloading areas to detect vapor escape and spills. Monitor locations and sampling frequency will be specified by the on-site safety director. It is anticipated that one ambient air monitor will be located at the loading area and one will be located at the unloading area.

3.6.5 Public Risk

The degree of public risk during bulk transport of liquid PCBs to the loading site will depend upon the transportation method selected and the proximity of the processing facility to the loading site. In general, public risk due to potential spills or vapor escape will be minimized when the dedrumming and ship loading facilities are coterminous. Pipeline transport eliminates the risks associated with collision or derailment. In the case of tank trucks, facilities which are mutually accessible by private roadways would reduce public risk since they obviate the need for transport on or near public roadways.

In the event that transport on or near public thoroughfares is required, the extent of public risk will be dependent upon the traffic and routing. Risks would be minimized by transport through areas of lowest habitation and along routes on which other traffic has been suspended. Although public risk during transport is difficult to assess, it will be minimized by proper routing and appropriate monitoring and contingency planning.

3.6.6 Contingencies

The key elements of contingency planning: preparedness, prevention, notification, and emergency procedures, will be generally discussed in the following sections. A detailed contingency plan will be prepared in accordance with RCRA regulations in 40 CFR 250,43-3 and Section 311 of the Clean Water Act upon selection of processing and docking facilities, bulk transport modes, and principal program participants.

3.6.6.1 Preparedness and Prevention--

Preparedness and prevention, as they apply to bulk transport operations, will include leak checks of all transport equipment, maintenance of replacement equipment, provision for emergency containment and cleanup equipment, and notification of local agencies prior to initiation of transport operations. Although transport may be by rail tank car, tank truck, or pipeline, the approach employed will be similar regardless of the selected mode.

Transport equipment will be leak checked prior to initiation of transport operations. Tank cars and tank trucks will be pressure tested before use. Additionally, valving will be observed uncapped during filling to detect leakage. Any leakage greater than a drip will preclude transport use until such leaks are repaired. Similarly, any leakage through rivets, seams, or couplings must be repaired prior to transport. Pipeline integrity will be verified consistent with American Society of Mechanical Engineers and DOT requirements.

Small leaks detected during operations should be contained in buckets or drums until all the contents can be safely pumped to an alternate transport vehicle or a holding tank. Large leaks should be contained in diked areas lined with fiberglass reinforced plastic until safe transfer can be performed. The filling of any leaking equipment will be immediately terminated and its contents will be transferred to an alternate unit.

Vapor pollution can be controlled by minimizing open handling of the wastes and equipping all transport equipment vents with activated carbon adsorbers. Open handling of PCBs will be limited to drip containment during coupling and uncoupling operations, and leak or spill containment.

A communications system will be used immediately by monitoring personnel and transport vehicle operators to report any unusual incident. All thoroughfares or rail crossings will be manned in an effort to minimize the potential for collisions, if feasible. All transport vehicles will travel at speeds consistent with safe practice for dangerous cargo.

Bags of absorbent materials and emergency equipment such as shovels, brooms, squeegees, pails, sandbags, and sheeting of fiberglass reinforced plastic should be prominently situated along the transport route or available in accompanying vehicles for use in emergency spill containment. Adequate personnel should be available at appropriate stations during transport to effect rapid emergency spill containment.

3.6.6.2 Emergency Procedures--

Detailed emergency procedures should be prepared consistent with the selected transport modes, routings, and facility locations. Spent adsorbent and contaminated sheeting and sandbags should be placed in separate storage drums, properly marked, and stored for future disposal. Decontamination subsequent to containment, will include clearly marking affected land areas for penetration tests. Upon determining the extent of penetration, affected soil should be removed, placed in empty drums, properly marked and stored for future disposal. To the extent that it is feasible, contaminated waters should be collected for subsequent disposal.

Emergency notification procedures are identical to those detailed in Section 3.4.2.10 with the added provision that all notifications required by local regulations will be carried out.

3.7 SHIP LOADING

Loading of PCBs onboard the incinerator vessel can be conducted using procedures adapted from those developed for Herbicide Orange operations (16, 17). Monitoring of ship loading should be performed to ensure personnel safety. A detailed contingency plan should be developed including spill protection and emergency procedures. Wastes loaded onboard the ship must have a chlorine content not greater than 30 to 40% and a net heating value of at least 6300 Btu/lb, i.e., they must be able to support combustion without auxiliary fuel.

3.7.1 Administrative and Legal Constraints

Federal regulations controlling the entrance of toxic pollutants into U.S. waters are applicable to ship loading of PCBs at U.S. ports. They include:

- Resource Conservation and Recovery Act
- Hazardous Materials Transportation Act
- Ports and Waterways Safety Act
- Clean Water Act

The National Oil and Hazardous Substances Pollution Contingency Plan also defines responsibilities and notification procedures for controlling spills of hazardous materials into U.S. Coastal waters. In addition, each port facility may impose local requirements on loading procedures and spill prevention measures. Pilots may also be required onboard to direct movement of the incinerator vessel while entering and leaving port.

3.7.2 Loading Procedure

There are two distinct areas of responsibility in shiploading operations: shipboard and land-based. Using the Vulcanus as an example, the ship has detailed procedures for shipboard activities: connecting the loading hose to the loading manifold, operating valves to load the various tanks, gauging the tanks, and monitoring for shipboard leakage. The ship's procedures do not cover, for example, operating the land-based pumping system and connecting the pumping system to the PCB transportation vehicle, pipeline, or dockside tank. The responsibility for obtaining an adequate pumping system and preparing land-based procedures for ship loading should rest with the dedrumming contractor and the ship owner. Close coordination between EPA, the dedrumming contractor, the monitoring contractor, the ship, and other parties, such as the U.S. Coast Guard (USCG), will be necessary.

The risk of environmental contamination from a potential spill can be minimized by isolating the land-based pump(s) within a basin constructed with sandbags and lined with impermeable plastic. Flexible transfer hose should be used, with containers and absorbent material positioned to catch possible leaks at connections.

3.7.3 Personnel Safety

Appropriate protective clothing will be the chief means of assuring personnel safety during loading. Personnel who make connections to the transport vehicle and the pumping system and who tend the pumping system will be provided with impervious boots and aprons, fresh coveralls daily, goggle-type safety glasses, and heavy rubber gloves. Respiratory protection will be employed as required, consistent with the specific transfer operations performed. At shift change, boots, aprons, and gloves should be hosed off and stored at the loading site. Pump operators should shower and change into clean clothing in facilities located as close as possible to the loading site. Used coveralls will be laundered after each use. Precautions should be taken to avoid discharge of contaminated wash water.

Once the exact location of the loading facilities have been determined, a more detailed safety plan will be written. The boundary isolation concept used onboard the ship to maintain clean areas should be adapted to loading operations. Essentially, the area around the transport vehicle-pump system-ship interfaces will be defined as contaminated. All other areas will be designated as clean. Showers, fresh clothing, and used clothing should be available right at the dock, if possible. If this is impossible, however, boots, aprons, and gloves should be left at the dock. Fresh coveralls should be donned before leaving the dock, if possible.

If donning fresh coveralls at the dock is impossible, the vehicle returning personnel will be designated as contaminated. Personnel will shower at the processing facility prior to leaving the plant. Fresh coveralls will be donned at the processing facility by personnel going on shift for pumping duties.

3.7.4 Monitoring

The chief means of monitoring during loading operations will be visual. The ship's engineers are in attendance continuously during loading, checking for leaks and monitoring tank filling. Onshore pump operators will maintain continuous surveillance of all connections, joints, etc. in the pumping system during pumping operations.

The likelihood of release of measurable quantities of liquid PCBs to the air is considered quite low. Thus, use of a single monitoring instrument at dockside should be sufficient.

3.7.5 Public Risk

Public risk is low during ship loading operations. The population around docks is small. If the ship loading dock is a private one dedicated to waste handling, the possible exposed population will be very small. The only situation that could give rise to substantial risk would be extreme fire damage to the ship, which could result in releasing substantial toxic cargo into the port area. Potential spills resulting from leaks or broken fittings or joints in the pump system would be small because operators will be in continuous attendance.

3.7.6 Contingencies

A more detailed contingency plan will be developed once the ship loading site and other factors have been defined. This section describes some feature which may be included in such a contingency plan.

3.7.6.1 Control of the Ship--

The U.S. Coast Guard (USCG) Captain of the Port will control the movement of the ship in the harbor and exercise all necessary actions to prevent accidental collision in the harbor, including restricting the movement of other vessels. The EPA Program Director will notify the USCG Marine Safety Office of the date ship loading is expected to start and the estimated date and time of departure. The USCG will make a safety broadcast Notice to Mariners advising ship traffic to exercise caution in the vicinity of the harbor.

Ship loading operation hours need to be defined, but may be limited to daylight hours. Upon departure, tugs may be necessary to assist the loaded vessel. The USCG, in coordination with the Port Authority, will escort the vessel from the port to the open sea.

3.7.6.2 Problems in the Harbor--

Any incident involving the ship or loading operations will be reported as soon as possible to the EPA On-Site Director (EPA-OSD). The time and nature of the problem, the impact on cargo and ship loading, and requirements for assistance must be reported. A detailed log of problems will be maintained by the ship's Master and by the EPA-OSD.

Actions taken will depend on the nature of the problem. The goal is zero release of PCBs to the environment. If the problem does not pose a threat of cargo spill, all normal maritime casualty procedures will be followed. If the Port Captain determines that the cargo must be removed prior to moving the vessel, he will advise the EPA-OSD who will arrange for removal. The charterers of the vessel will arrange for towing and effect repairs satisfactory for Coast Guard clearance. During such repairs, the EPA-OSD, in coordination with USCG, will take all reasonable measures to maintain the integrity of the cargo and environment.

3.7.6.3 Spills in the Harbor--

Containment equipment should be available to mitigate spills. In the event of a spill in the harbor, the EPA-OSD and/or the ship's Master will notify immediately the appropriate EPA Regional Office, the USCG's National Response Center, and EPA's Emergency Response Division, Office of Hazardous Emergency Response.

The EPA-OSD and ship's Master will also take action to prevent further loss of PCB waste. Such actions might include: 1) isolation of the spill source by discontinuing pumping operations; or 2) pumping cargo from the faulty container, tank car, or vessel cargo tank to an empty, prepositioned tank truck or tank car on site.

The responsibility for initiating cleanup action resides with the EPA-

OSD. His decisions will be based on the amount of waste spilled, the location of the spill, accessibility or depth of water, and reasonable prospects of recovery. Small spills, drips, or leaks can be contained using "oil-sorb". Large spills on land may be pumped into a prepositioned tank truck or rail car.

3.8 PUBLIC NOTIFICATION AND PARTICIPATION

The PCB Regulations do not explicitly discuss public notification or participation in the disposal process. However, there is ample evidence of local public concern about and opposition to hazardous waste transport and disposal operations. Thus, local support for the PCB disposal action will be very helpful, if not essential. This section will describe steps that can be taken to enhance public support by providing for an informed public. It will also describe some pitfalls to be avoided.

EPA recently published a proposed policy on public participation in Agency decision-making and rulemaking (45 FR 28911). To ensure effective public participation, EPA defined five basic tasks to be performed. These are described briefly below.

- Identification. Those groups or members of the public who may be interested in or affected by the action should be identified.
- Outreach. Information about the PCB disposal action must be conveyed to the public through mailings, personal communications, public service announcements, media briefings or ads, and other means. The information must include background, timetables, summaries of technical material, and, if possible, a description of social, economic, and environmental consequences.
- Dialogue. The responsible official and interested or affected members of the public must be able to exchange views and explore issues. The dialogue may take several forms: meetings, workshops, hearings, or correspondence. Timely dissemination of information is crucial.
- Assimilation. The results of the "outreach" and "dialogue" tasks must be assimilated into the final decision, and the responsible official must demonstrate that he has understood and considered public concerns.
- Feedback. The responsible official must provide feedback to interested parties concerning the outcome of the public's participation. This feedback must state the action that was taken and indicate the effect that public participation had on the action.

Public concern caused considerable delays in performing a PCB destruction test in an industrial boiler at General Motors' Chevrolet plant in Bay City, Michigan. Zelenski, Hall, and Haupt (23) reported on deficiencies in the public participation process. The major deficiencies were:

- The public was not informed of the proposed permit application in the early planning stages.
- Special interest groups were not informed of the proposed permit application in the early planning stages.
- Plant personnel were not informed in the early planning stages.
- Information needs of the public and special interest groups were not adequately anticipated.
- Information supplied was perceived as too technical.
- There was a lack of communication, coordination, and clearly defined responsibilities between participants in the permit approval process.

Zelenski, Hall, and Haupt (23) made a number of recommendations, several of which are basically the same as defined in EPA's proposed policy on public participation:

- Identify the concerned public and groups.
- Communicate with the concerned public and groups.
- Develop a relationship of cooperation with the public and groups.
- Determine the level of support and incorporate that in plans for the proposed action.

It is recommended that a public participation work plan be developed for the PCB disposal action. Such a plan should consider potential public concerns which may arise from the following:

- Transportation of PCBs from and through areas of high population density
- Processing and storage of PCBs at a land-based facility
- Incineration of PCB wastes at-sea.

4. AT-SEA OPERATIONS

This section describes the at-sea operations of the PCB disposal program, including incineration and ship cargo tank decontamination procedures. Also described are criteria and procedures for selecting an at-sea incineration site and obtaining an ocean dumping permit.

4.1 INCINERATION SITE SELECTION

The Marine Protection, Research and Sanctuaries Act (MPRSA) gives the EPA authority to regulate at-sea incineration. Pursuant to MPRSA, EPA has promulgated regulations and criteria for ocean dumping, which include incineration at sea (40 CFR 220-229). Ocean incineration sites are designated by EPA using criteria set forth in 40 CFR 228, based on environmental studies of the site and adjacent regions.

Two ocean incineration sites were the prime candidate sites for incineration of liquid PCBs at sea. They were:

- Gulf Ocean Incineration Site (GOIS), located off the Louisiana coast in the Gulf of Mexico, Reference 24.
- Atlantic Ocean Incineration Site (AOIS), off the coast of New Jersey in the Atlantic Ocean, now being considered for designation, Reference 25.

The Gulf Ocean Incineration Site was selected for incineration of PCB wastes. Factors considered in selecting this site are outlined below.

4.1.1 Legal Considerations

The major legal consideration distinguishing the two incineration sites mentioned above is that the GOIS has already been designated by EPA for use as an ocean incineration site for organochlorine wastes (24), but the AOIS has not yet been designated (25). A final environmental impact statement for the AOIS is in preparation, and the site may be designated officially by the end of 1981. However, for program planning purposes, the GOIS was chosen to avoid delaying the project should designation of the AOIS be held up.

Another major legal consideration is that the Gulf Ocean Incineration Site designation expired 15 September 1981 (40 CFR 228.12 (b)(1)). Current estimates of the PCB disposal schedule (Section 5) put at-sea incineration well beyond this date. Therefore, the period of use of the GOIS must be extended.

4.1.2 Technical Considerations

Perhaps the major technical considerations in selecting an incineration site will be the suitability of the associated land-based facilities. Suitability will be determined by:

- Proximity of land-based support facility
- Presence of adequate and safe means for conveying liquid PCBs from the land-based facility to the incinerator ship
- Physical configuration of port facilities

Other technical considerations concern strictly at-sea operations. For example, weather at sea may be a concern. Winter weather in the AOIS would be considerably harsher than in the GOIS and would make sampling onboard the ship much more difficult.

4.1.3 Other Considerations

Socio-political considerations arising from the aforementioned legal considerations could be as important for timely project completion as legal or technical constraints. Public opinion in the coastal areas near any proposed ocean burn zone should be carefully considered. Public reaction may prove quite negative toward any special designation of an incineration site off the New Jersey coast prior to completion of the official site designation process unless an adequate public participation work plan (Section 3.8) is prepared and implemented.

The extent of public risk during at-sea operations is generally limited to exposure to PCBs accidentally spilled during loading or steaming to the incineration site. Public risk during normal incineration operations is expected to be quite low since the remoteness of any EPA designated incineration site will preclude impingement of the incinerator plume on populated areas. Public risk considerations might make a small port in a sparsely populated area more desirable than a major port in a metropolitan area. However, a major port facility would more likely be better equipped to handle normal project operations as well as emergencies which could occur.

4.2 PERMIT REQUIREMENTS

A party desiring to incinerate at sea must apply for a permit to do so in accordance with procedures outlined in EPA's Ocean Dumping Regulations, 40 CFR 220-229. The Ocean Dumping Regulations set forth procedures for filing and criteria for evaluating permit applications, define the steps in the permit approval process, and state certain requirements as to the content of permits. In addition to the requirements of the Ocean Dumping Regulations, the permit to incinerate PCBs at sea must meet the requirements of the "Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matters" (London Dumping Convention), to which the United States is a signator. Protocols arising from the London Dumping Convention are administered by the Intergovernmental Maritime Consultative Organization (IMCO). At the Third Consultative Meeting of the contracting parties to the London Dumping Convention in October 1978, IMCO adopted mandatory regulations for the control of incineration at sea which were incorporated in the Convention. Recommended technical guidelines on at-sea incineration were also adopted but are not yet mandatory. In March 1979, these IMCO regulations went into effect in the United States. Furthermore, some provisions of RCRA apply to acquisition of a permit for at-sea incineration. This section will discuss the administrative procedures and requirements necessary to obtain and comply with an ocean dumping permit.

4.2.1 Ocean Dumping Permit Requirements

The Ocean Dumping Regulations prescribe certain steps in order to obtain a permit. The process is described below. The process is initiated with the filing of a written permit application. (A decision is needed as to whether the Administrator or the appropriate Regional Administrator will issue the permit.)

- Section 222.1 specifies that final action on any permit application will, to the extent possible, be taken within 180 days from the date a complete application is filed.

- Section 222.2(a) specifies that, within 30 days of the receipt of the initial application, the applicant will be issued notification of whether his application is complete and what, if any, additional information is required. (Sections 221.1 - 221.4 describe the information required.)

- Section 222.2(b) specifies that, within 30 days of receipt of a completed application, the Administrator or the Regional Administrator will publish notice of the application including a tentative determination with respect to issuance or denial of the permit.

- Section 222.3 describes and specifies the contents of such notices.

- Section 222.3 (a) (3) requires a brief description of the procedures set forth in Section 222.5 for requesting a public hearing.

- Section 222.5 states that the Administrator or Regional Administrator may determine to hold a public hearing without waiting for a request, procedures for which are specified in Section 222.4.

- Section 222.3 (c) specifies to whom (individuals and agencies) notifications of Section 222.3 are to be sent. This section also states that failure to send Section 222.3 (c) notices to certain parties will not invalidate subsequent proceedings and that failure of consulted agencies to respond within 30 days of notice is taken as approval of the action.

- Section 222.6 and 222.7 describe the Presiding Officer and the conduct of the hearing. (The Administrator or Regional Administrator must designate the Presiding Officer.)

- Section 222.8 prescribes that, within 30 days following adjournment of the public hearing, the Presiding Officer will forward to the Administrator or Regional Administrator written recommendations relating to the issuance or denial of the permit.

- Section 222.9 (a) prescribes that, within 30 days after receipt of the Presiding Officer's recommendations, the Administrator or Regional Administrator will make a determination with respect to the issuance or denial of the permit. He will also notify the applicant and all persons who attended the hearing of his determination and the basis for the determination.

- Section 222.9 (b) specifies that the determination to issue or deny the permit cannot take effect sooner than
  - 10 days after such notice in Section 222.9 (a).
  - 20 days after such notice in Section 222.9 (a) if a request for an adjucatory hearing is filed in accordance with Section 222.10 (a) and if the Administrator or Regional Administrator denies the request in accordance with Section 222.10 (c).
  - The date on which a final determination has been made following an adjucatory hearing held pursuant to Section 222.11.
- Section 222.9 (b) requires that a copy of the permit be sent to the appropriate U.S. Coast Guard District Office.

As part of the permit application, information must be included concerning the organizations involved in the disposal, the waste to be incinerated, and the details of the disposal operation. In addition, a statement of the need for at-sea incineration, an evaluation of alternative disposal methods, and an assessment of the environmental impacts of the proposed action must be included. Thus, an environmental impact assessment for the project may need to be prepared.*

General criteria for approval of ocean dumping permit applications are described in 40 CFR 227. These criteria consider 1) the need for and alternatives to the proposed action, 2) the effects of the action on the environment, and 3) the effects on esthetic, recreational, and economic values and other uses of the ocean.

Until specific criteria to regulate at-sea incineration systems are promulgated by EPA, permits granted for incineration at sea will be either research permits, special permits, or interim permits. Agency policy in the past has been to grant a research permit for the first burn of a particular waste, and a special permit for subsequent burns. Technical requirements for at-sea incineration operations are not specifically detailed in the Ocean Dumping Regulations. They are established on a case-by-case basis. Administrative requirements stated in the Ocean Dumping Regulations include the following:

---

* It should be noted that, in general, EPA is exempted from preparing an environmental impact statement (EIS) on actions it sponsors. The courts have found EPA to be exempt from the EIS requirements for regulatory actions under certain Acts, including MPRSA, because EPA actions under these statutes are undertaken with sufficient safeguards to ensure a functionally equivalent analysis of National Environmental Policy Act requirements (See Maryland v. Train, 415 F. Supp. 116, District Court, Maryland, 1976).

- The material to be incinerated must be adequately described in the permit, and only that material may be burned.
- The precise times and locations of incineration must be specified.

A number of technical conditions were included in permits issued for the at-sea incineration of Herbicide Orange (26). These conditions were determined based on the unique properties of the herbicide. For example, the research permit specified both maximum and minimum waste feed rates. It also required collection of marine water and plankton samples from the incineration site before and after incineration of waste. Other requirements specified in these permits were as follows:

- The Permittees are authorized to heat up incinerators with fuel oil while en route to the site but may not incinerate the described wastes except at the site which is defined in the permit.
- During start-up, waste shall not be fed into the incinerators until a flame temperature of 1280°C has been reached in the furnace, and only one burner at a time shall be changed over to the waste. The start-up temperature of 1280°C must be reached before the next burner is changed over to waste.
- Monitoring of the furnaces for temperature and for completeness of combustion shall be in effect during the change-over. A record of temperature shall also be maintained during this time.
- The incinerator flame temperature shall be greater than 1250°C when burning waste.
- An automatic shut-off device shall be in operation on both furnaces set to turn off the flow of waste if the flame temperature drops below 1250°C.
- Incineration shall take place in the presence of sufficient excess air to ensure a 3 mole percent minimum oxygen content in the combustion product gas.

- The combustion efficiency of the incineration and destruction efficiency during the incineration will be at least 99.9 percent complete. If the efficiency level falls below 99.9 percent, the incinerators will be shut down immediately until corrective measures which assure 99.9 percent combustion and destruction efficiency are applied.
- A manual log shall be kept and the following information recorded at 1-hour intervals:
  a) Time, date
  b) Controller temperature reading
  c) Waste feed rates
  d) Switching of waste tanks
  e) Wind speed and direction
  f) Location
- A device for the addition of ammonia to make a visible plume will be installed.
- Permittees shall ensure their position during transport and within the discharge site at all times by on-board navigational aids and shall maintain documentation of position.
- Permittees shall have installed and in operating condition a radio or other communications devices which are capable of voice transmission to the mainland from the vessel when en route to the incineration site, and during the incineration of the waste in the designated site. The frequency of reporting and information to be transmitted shall be set forth in a Contingency Plan, included as appendix to the permit.
- During the burns the Permittees shall transmit the following information to EPA Headquarters every 24 hours:
  a) Operating temperatures
  b) Average combustion efficiency
  c) Significant malfunctions/incidents
- The Permittees shall monitor for carbon monoxide, carbon dioxide, oxygen, and other parameters in accordance with the monitoring plan contained in an appendix to the permit.
- The Permittees shall comply with all provisions of the comprehensive safety plan set forth in an appendix to the permit.

The above conditions illustrate some of the technical requirements which were included in previous permits for at-sea incineration of a highly toxic waste. Some of these precedents may be applicable for incineration of PCBs. However, the nature of the waste will be the determining factor in setting conditions for PCB incineration.

4.2.2 IMCO Requirements

IMCO has developed regulations and technical guidelines for at-sea incineration. Some IMCO regulatory requirements would be satisfied by adhering to the requirements listed in Section 4.2.1 which applied to the incineration of Herbicide Orange. For instance, IMCO requires an adequate characterization of the waste to be burned, a minimum flame temperature of 1250°C,* combustion and destruction efficiencies in excess of 99.9 percent, automatic waste shut-off devices, and monitoring of carbon monoxide and carbon dioxide in the stack gas. Additional requirements imposed by IMCO regulations include the following:

- No black smoke or flame extension is allowed above the exit plane of the stack.
- Replies to radio calls must be made promptly during incineration operations.
- Records must be kept on
  - temperature of incineration (continuous)
  - vessel position, course, and speed
  - fuel and waste feed rates (continuous for liquids)
  - date and time of incineration and a record of waste being burned

IMCO Regulation 4 sets requirements which may be subject to interpretation for the PCB disposal project. Regulation 4 requires that special studies be conducted for wastes meeting either of the following criteria:

- Those for which doubt exists as to their thermal destructability (such wastes are listed in IMCO Technical Guidelines), in which case pilot tests must be undertaken.
- Those for which doubt exists as to the efficiency of combustion, in which case extensive stack monitoring is required.

PCBs may meet these two criteria. Some doubt exists as to whether pilot tests on land would be required on PCBs. However, because sufficient data exist on thermal destruction of PCBs, these tests will probably not be required. The extensive stack monitoring referred to would include, in addition to those requirements already mentioned, the following:

---

* Unless adequate destruction at lower temperatures is substantial by test results.

- Total organic chlorine
- Total hydrocarbons

Such additional stack gas monitoring may be required for a research permit.

IMCO Technical Guidelines will be considered in the permitting process. Some or all of these Guidelines may be included in the permit, however, inclusion is not mandatory. Some of the Guidelines would be satisfied by complying with the above requirements. Other relevant technical guidelines set forth by IMCO are the following:

- Tank washings and contaminated bilge water should be incinerated at sea.
- Incineration locations and schedules should be known to relevant maritime authorities.
- Regular radio warnings should be broadcast during incineration operations.
- Incinerator ships should carry a valid IMCO Certificate of Fitness, and comply with U.S. Coast Guard design, construction and operation requirements.
- Tanks from which waste is taken for incineration should be recorded during incineration.
- Meteorological conditions should be recorded during incineration.
- If possible, information on the chemical and physical transformations of the waste after incineration should be known, particularly in regard to formation of new compounds and composition of ashes or burned residues.
- Air feed rate should be recorded.
- Temperature controls should be based on wall temperature measurement, using 3 or more thermocouples per incinerator.
- A wall temperature should be defined below which waste flow should be automatically shutoff. This temperature should be 1200°C, unless test results on the incinerator demonstrate that required combustion and destruction efficiencies can be achieved at a lower temperature.
- Residence time on the order of 1 second or longer at 1250°C under normal operation should be maintained.
- Automatic shut-off systems, including flame sensors for each burner, should be used to stop flow to that burner in the event of flameout.

4.2.2 RCRA Permit by Rule Requirements

Owners or operators of at-sea incineration vessels do not have to submit RCRA permit applications. Such a person is deemed to have a RCRA permit (a permit by rule) if he

- has a valid ocean dumping permit,
- complies with the terms of that permit, and
- complies with the following RCRA manifest, recordkeeping and reporting requirements.
  - 40 CFR 264.11, Identification nymber
  - 40 CFR 264.71, Use of manifest system
  - 40 CFR 264.72, Manifest discrepancies
  - 40 CFR 264.73 (a) and (b) (1), Operation record
  - 40 CFR 264.75, Annual report and
  - 40 CFR 264.76, Unmanifested waste report

4.3 INCINERATION OPERATIONS

Incineration operations shall include all shipboard activities related to the thermal destruction of PCBs. Requirements for these procedures will be included in the at-sea incineration permit. Descriptions of an incinerator vessel and plans required for incineration operations are presented in the following sections.

4.3.1 Administrative and Legal Constraints

At-sea incineration operations will be conducted in accordance with an EPA approved ocean dumping permit. This permit will cover transportation of wastes from the docking facility and incineration operations within the designated incineration site. Requirements for minimum incineration temperatures, monitoring, and efficiencies will be specified in the permit (Section 4.2).

4.3.2 Permit Data Requirements

The permit will include requirements for data necessary to confirm that efficient PCB destruction is maintained throughout the burn. At a minimum, monitoring should be performed for the following parameters:

- Incinerator temperature
- Waste feed rate

- O_2, CO, CO_2 and PCB in the combustion gases

Combustion efficiency, based upon CO and CO_2 measurements will be specified in the incineration permit. Minimum O_2 levels may also be specified. Automatic shutoff devices will terminate waste flow if incinerator temperatures fall below a predetermined limit. Other recordkeeping requirements which could be imposed as permit conditions were discussed in Section 4.2.

4.3.3 Description of the M/T Vulcanus

4.3.3.1 General Specifications--

The M/T Vulcanus, originally a cargo ship, was converted in 1972 to a chemical tanker fitted with two large incinerators located at the stern. The vessel meets all applicable IMCO requirements concerning transport of dangerous cargo by tanker. The ship is operated by the Chemical Waste Management subsidiary of Waste Management, Inc., Oak Brook, Illinois.

The ship has an overall length of 102 meters, a beam of 14.4 meters, and a maximum draft of 7.4 meters. It is able to operate worldwide. Two diesel engines drive a single propeller to give cruising speeds of 10 to 13 knots. Her crew numbers 18; 12 to operate the vessel and 6 to operate the two incinerators.

4.3.3.2 Tanks and Pumps--

The Vulcanus is a double-hull, double-bottom vessel. Waste is carried in 15 cargo tanks which range in size from 115 to 574 m^3 with an overall capacity of 3503 m^3. There are 5 large center tanks and 5 smaller tanks each on the port and starboard. Tanks are filled through a manifold on deck using a dockside loading pump. During normal operation the waste tanks can be discharged only through the incinerator feed system. Provisions exist, however, for discharging the cargo into the ocean if an emergency arises. Piping system construction makes it possible for any tank to be connected to either incinerator and for cargo to be transferred from one tank to another.

The space between the two hulls is used for ballast. Ballast tanks are filled with seawater and emptied independently as required to trim and balance the ship. Fuel oil is carried in tanks under and in the engine room. The engine room is separated from the cargo tanks by double bulkheads. The pump

TABLE 3. SPECIFICATIONS OF THE M/T VULCANUS

Length overall	101.95 meters
Breadth	14.40 meters
Draft, maximum	7.40 meters
Deadweight (DWT)	4,768 metric tons
Speed	10-13 knots
Tank capacity	3,503 cubic meters (cu m)
Number of tanks	15, ranging in size from 115 cu m to 574 cu m
Tank coating	No coating in tanks, pipes, pumps, etc. All equipment consists of low carbon steel
Loading equipment	Not available, but can be placed on board, if required
Hose connection	10.2, 15.2, and 20.3 centimeters (4,6, 8 inches)in diameter
Safety equipment	Specially designed for this task and in accordance with latest regulations of IMCO, Scheepvaart-Inspectie (The Hague)
Waste to be processed	Must be liquid and pumpable. May contain solid substances in pieces up to 5 centimeters in size. Must not attack mild steel
Incinerators	2
Per incinerator:	
Overall height	10.45 m
Combustion chamber	
OD	5.5 m
ID	4.8 m
Stack (top)	
OD	3.8 m
ID	3.4 m
Waste feed (max)	12.5 metric tons/hour
Combustion air (max)	90,000 m^3/hour
Burners (Vortex type)	3
Volume	120 m^3
Residence time	1.0 sec at 1500 °C (calculated)

room and generator room are situated between the engine room and the waste tanks.

4.3.3.3 Incinerator System--

Waste is burned in two identical refractory-lined furnaces located at the stern. Each incinerator consists of two main sections, a combustion chamber and a stack, through which burning gases pass sequentially (Figure 2). This dual chamber configuration, which is characteristic of most high intensity combustion systems, uses the first chamber for internal mixing and the second for adequate residence time. Table 3 lists characteristics of the incinerators.

Combustion air is supplied by large fixed speed blowers having a rated maximum capacity of 90,000 m^3 per hour for each incinerator. Adjustable

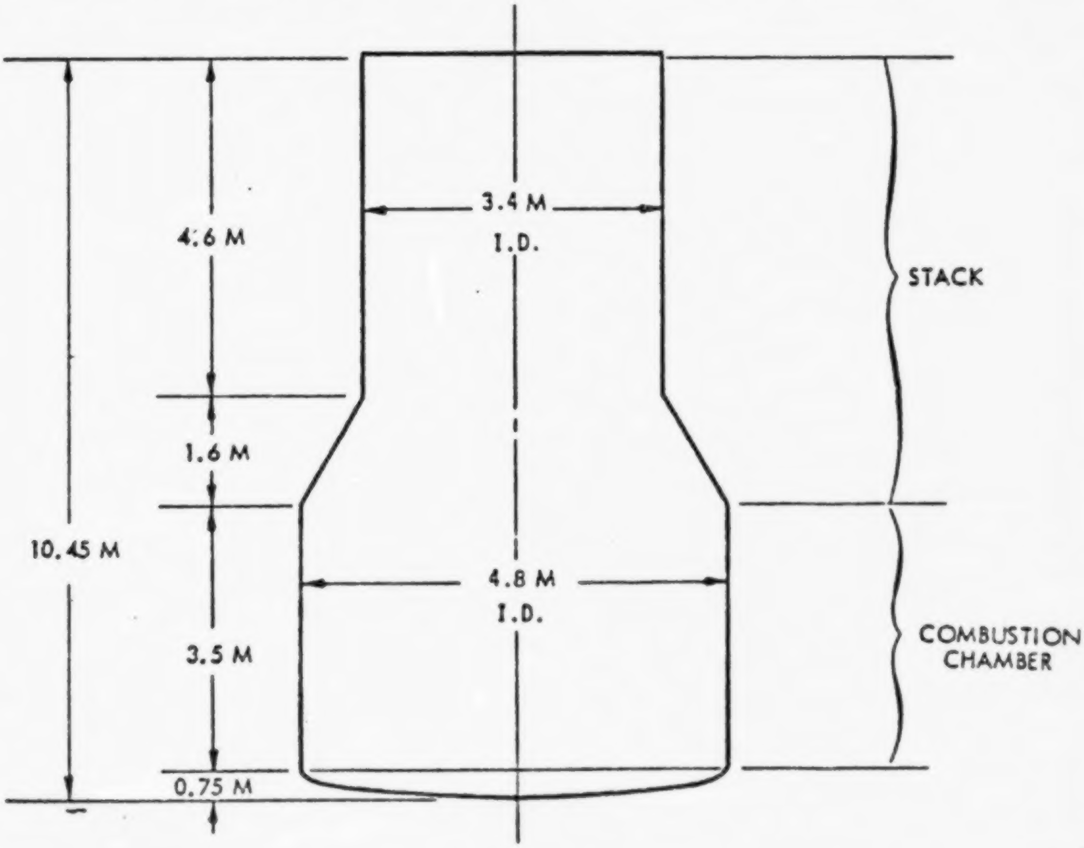


Figure 2. Incinerator Configuration

vanes are incorporated in the combustion air supply system. When they are deflected, the system pressure drop is increased and the flow rate is reduced. Although no instrumentation is installed to monitor air flow rate, normal operation is stated by the ship's chief engineer to be between 75,000 and 80,000 m^3 per hour at ambient conditions.

Liquid wastes are fed to the combustion system by means of electrically driven pumps. Upstream of each burner supply pump is a device (Gorator) for reducing the solids in the waste to a pumpable slurry. The Gorator also acts as a mixing pump by recirculating the waste through the waste tank. Power for the blowers, pumps, and other parts of the incinerator system is supplied by two diesel generators with a total capacity of 750 kW at 440 volts and 60 hertz.

Three burners of the vortex type are located at the same level on the periphery and near the base of each incinerator. The burners are of a rotating cup, concentric design and deliver waste or fuel oil through a central tube to an atomization nozzle, where it meets high velocity air delivered through an annulus. The burners are positioned as shown in Figure 3. Typically, burners of this type have a turndown ratio of 5:1.

Three-way valves are utilized on each burner to provide either waste feed, fuel oil feed, or a shutoff condition. Waste and fuel oil cannot be valved into a burner simultaneously; however, alternate burners can be operated with fuel and waste to achieve higher or lower combustion temperatures if necessary, depending on the relative heat contents of the fuel oil and waste.

Periodically the burners require cleaning. They are normally cleaned one at a time with the remaining two firing waste. Cleaning is easily accomplished because the burners are readily accessible. Each burner has a vertical pivot so that it can be swung out of the furnace. The opening left by this operation is temporarily closed by a cover. The burners are cleaned by a metal tool which is pushed through the burner.

4.3.3.4 Recording and Control Equipment--

Waste flow measurement--Sounding the depth of waste in each tank with a tape is the usual method of determining burn rate. This method is only useful in port or in calm seas (i.e., minimum ship roll). During the actual

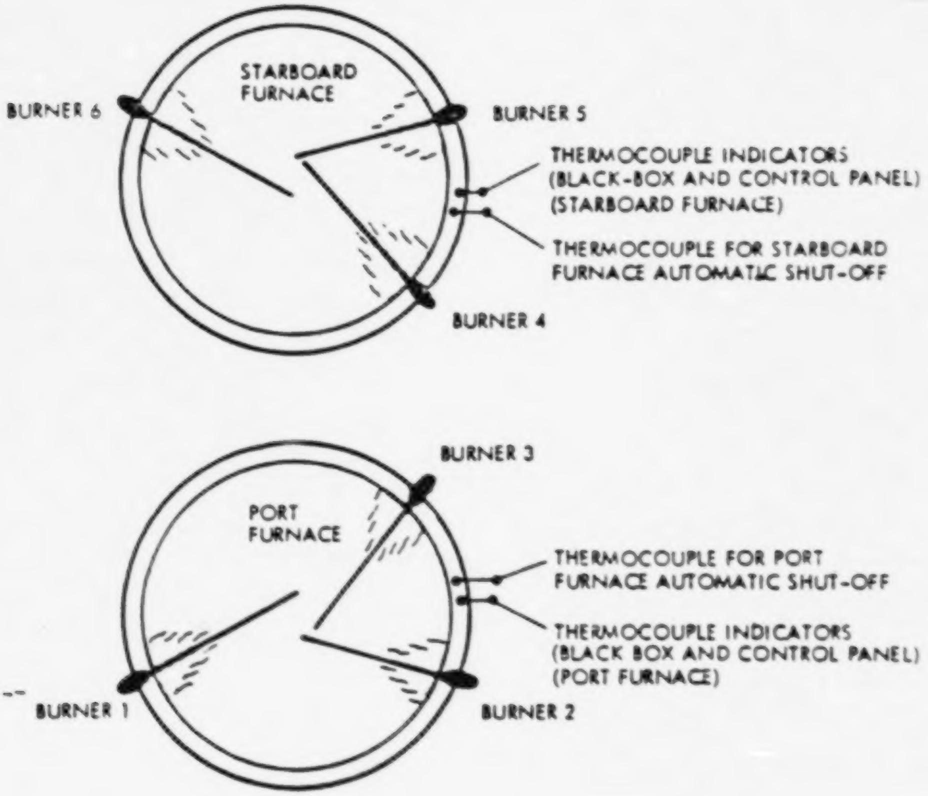

STARBOARD FURNACE
BURNER 6
BURNER 5
THERMOCOUPLE INDICATORS (BLACK-BOX AND CONTROL PANEL) (STARBOARD FURNACE)
THERMOCOUPLE FOR STARBOARD FURNACE AUTOMATIC SHUT-OFF
BURNER 4
BURNER 3
PORT FURNACE
THERMOCOUPLE FOR PORT FURNACE AUTOMATIC SHUT-OFF
THERMOCOUPLE INDICATORS (BLACK BOX AND CONTROL PANEL) (PORT FURNACE)
BURNER 1
BURNER 2

Figure 3. Incineration system - burner and thermocouple locations.

burns, the total time is recorded for emptying each tank and a time average waste feed rate is determined.

Reference 27 described testing of several continuous waste flow measurement devices onboard the M/T Vulcanus. These instruments were an ultrasonic flow meter, affixed to the outside of waste carrying pipes, and a vortex shedding flow meter, the sensing element of which was installed inside waste carrying pipes. The sensor packages were in the incinerator room; the electronic packages were installed in a cabin. Both units functioned well over a period of several months. The ultrasonic unit is preferable because it mounts on the outside of waste flow pipes and is thus unsusceptible to clogging or erosion by the waste.

Regulations recently adopted under the London Dumping Convention require capability for continuous waste flow measurement. While incinerator ships, such as the Vulcanus, which were operating before 1 January 1979 are exempt from this regulation, it is recommended that this capability be installed and used for this incineration project.

Wall temperature measurements--Temperatures during operation of the incinerators are measured by three platinum/platinum-10% rhodium thermocouples in each incinerator. Two are located in a well opposite one of the burners (Figure 3). One thermocouple is located approximately 1.3 cm from the inside surface of the refractory lining. This thermocouple provides temperature information to the automatic waste shut-off system and is called the controller thermocouple. The second thermocouple, approximately 4 cm from the inner surface of the firebrick, is referred to as the "indicator" because it provides temperature information to a panel located in the incinerator control room and to a panel located on the bridge. The third thermocouple is mounted in each stack about 1 foot above the junction of the conical section with the vertical section. Temperatures indicated by the stack thermocouples are also displayed on the bridge.

The thermocouples used to activate the automatic waste shut-off system and the recording equipment have been quite reliable and durable according to personnel of the M/T Vulcanus.

4.3.3.5 Emergency Automatic Waste Shut-off--

The following description of the automatic waste shut-off system utilized by the M/T Vulcanus is based upon verbal description of the system by the ship's engineering staff.

The waste shut-off system consists of a number of different components which can effect the closing of spring-loaded solenoid valves which terminate waste flow to each burner while simultaneously shutting off power to the waste pumps. These spring-loaded solenoid valves are normally closed. During incineration, the valves are held open by an electrically-induced magnetic field. The waste flows through the solenoid valves until the electrical current is interrupted by a malfunction in the incineration system. Once interrupted, the malfunction must be repaired and restart procedures implemented before incineration can continue. These restart procedures require fuel oil start-up if the incinerator has dropped below a specified minimum temperature.

The automatic shut-off system will stop waste flow (or fuel oil flow) to the affected burner(s) and shut off power to the waste pumps when any one of the following malfunctions occur:

- Waste pump overload.
- Combustion air fan motor overload.
- Burner pump overload.
- Steering air (directs and shapes burner flames) or combustion air failure to reach an incinerator burner.
- Open burner: A mechanical switch interrupts the electrical current when the burner swings open or away from the incinerator wall (usually opened to remove residue during burner cleaning).
- Flame out: A light sensing resistor is located directly above each burner to monitor the flame. This resistor operates by viewing the flame and amplifying and conditioning the signal. Output of the sensor opens and closes several sets of contacts, half of which are normally closed and half normally open (under no flame condition). The normally closed contacts are not used in this system. Wires which conduct the electrical current used to induce the magnetic field for the waste shut-off valve are connected to the normally open position. During stable incineration, the contacts are closed and the electrical current flows through the contacts. This completes the circuit which produces the magnetic field holding the waste shut-off valve open. Upon flame blockage or electrical failure, the contacts connected will return to a normally open position, breaking the electrical current and removing the magnetic field from the waste valve, which in turn shuts by spring action.
- Temperature drops below minimum acceptable temperature: A thermocouple-controlled sensor interrupts the waste shut-off valve electrical current when the incinerator temperature drops below a preselected minimum temperature. The system used is the Plastomatic 2000 (supplied by Withoff-Phillips, Bremen, West Germany), previously discussed in Reference 27.

Once the flow has been stopped by the automatic shut-off system, any malfunctions are repaired, and the following restart procedures are implemented:

- Manully restart waste pumps (or start fuel oil pumps if incinerator temperatures are low enough to require fuel oil start-up).
- Depress ignitor button to provide ignition flame.

- Manually open emergency shut-off valve to initiate waste (or fuel oil) flow to burner.
- After stable combustion is attained, deactivate manual override of the emergency shut-off valves to return to automatic shut-off control condition.

4.3.3.6 Special Equipment--

Certain equipment has been installed on the Vulcanus because of its particular type of operation. These items of equipment are:

- Loran and Decca Navigational Systems: This equipment is needed in American (Loran) and European (Decca) waters in order to locate the ship precisely at all times. Celestial navigation has also been used to locate and keep the Vulcanus in the designated burn zone.
- Anemometer: This equipment measures the velocity and force of the wind. It is, therefore, useful in selecting an attitude of the ship during various wind conditions such that the plume produced may be directed away from the ship and its personnel.
- Radio Communication: The Vulcanus is equipped with SSB (single side band) and DSB (double size band) radio for voice and continuous wave communication; MF (medium frequency) and SW (short wave) telegraphy; Marifoon (VHF) (all channels) for close-in voice communication; and Semafoon (a private telephone communication system). For this program, a Hagenuck Synthesized Transceiver should be installed to permit voice communication over all marine frequencies. A radio is also located on the bridge so that the watch officer can hear marine broadcasts at all times.
- Optical Pyrometer: A portable optical pyrometer has been used during previous test programs to measure incinerator flame temperature. These measurements were taken daily using a Leeds and Northrup optical pyrometer operating in the 6500 angstrom range.

4.3.4 Recommended Monitoring, Sampling and Analysis Plan

The combustion product effluent stream from the incineration of liquid PCBs onboard the Vulcanus will be sampled utilizing three probes. Two ceramic probes (one in each stack) will be installed to divert the gases to an on-line monitoring system comprised of CO, CO_2, and O_2 analyzers; heated sample lines; and a gas conditioner. For a more comprehensive characterization of the combustion effluent, a water-cooled probe capable of traversing the starboard incinerator will divert a representative portion of the effluent stream to a benzene impinger train. The train will be used to acquire samples for onboard PCB analyses.

In addition to these monitoring and sampling activities, a variety of air, liquid, and solid samples will be taken. These samples include:

- Work space air samples
- Ambient air samples
- Wipe samples
- Miscellaneous samples of the fuel, waste feed, burner head residue, ship's water, and any other samples deemed necessary for completeness.

These samples will be analyzed as required by permit conditions and the safety plan.

It is recommended that a quality assurance plan be developed to supplement the monitoring, sampling, and analysis plan required by the ocean dumping permit.

The following sections describe the recommended monitoring, sampling and analysis plan in greater detail.

4.3.4.1 Monitoring Plan--

On-line monitoring of the concentration levels of CO, CO_2 and O_2 in both incinerator effluents may be accomplished by two complete duplicate systems, one primary and one spare. These gas levels will serve as indices of the effectiveness of the thermal destruction process. The on-line monitors will use one ceramic probe in each stack with heated line delivery systems. The manifold system is designed so that either a complete bank of instruments or one instrument can be operated, depending on the operational readiness of any given instrument.

Stack gas parameters to be monitored and appropriate instrumentation are given in Table 4. Instrumentation systems of this type have been used successfully in four different test programs on the Vulcanus.

On-line monitoring will be conducted for the duration of every stack sampling test and on days when stack sampling is not performed.

If monitoring of total hydrocarbons is required by permit conditions, an on-line instrument such as a Beckman Model 402 hydrocarbon analyzer with a flame ionization detector could be added to the monitoring system. This instrument has eight ranges, and can measure hydrocarbon concentrations from 0.05 ppm to 10%.

Monitoring of combustion temperature and waste feed rate will be performed as specified in Section 4.3.3.

TABLE 4. MONITORING PARAMETERS AND INSTRUMENTATION

Species Analyzed	Mfg. and Model	Analyzer Type	Instrument Range
Carbon Monoxide (CO)	Beckman 865	NDIR	0 - 200 ppm, 0 - 2000 ppm. 0 - 2%
Carbon Dioxide (CO_2)	Beckman 864	NDIR	0 - 4%, 0 - 8%, 0 - 15%
Oxygen (O_2)	Beckman 742	Electro-magnetic	0 - 5%, 0 - 10% 0 - 25%
	Taylor 0247A	Paramagnetic	0 - 5%, 0 - 10%, 0 - 25%

4.3.4.2 Sampling Plan--

Samples will be obtained during incineration of PCBs as follows:

- Stack samples - A benzene impinger train (Figure 4) equipped with water-cooled probe and heat traced Teflon line will sample stack gases from the starboard incinerator. Three one-hour samples will be collected during each stack test. Sampling will begin after steady-state incineration conditions have been attained.
- Work space air samples - Personal monitors fitted with Chromosorb 102 absorption tubes will be placed at several positions on the ship to monitor personnel exposure to atmospheric toxic materials.
- Air samples - Ambient air samples will be taken at specific locations using a gas syringe.

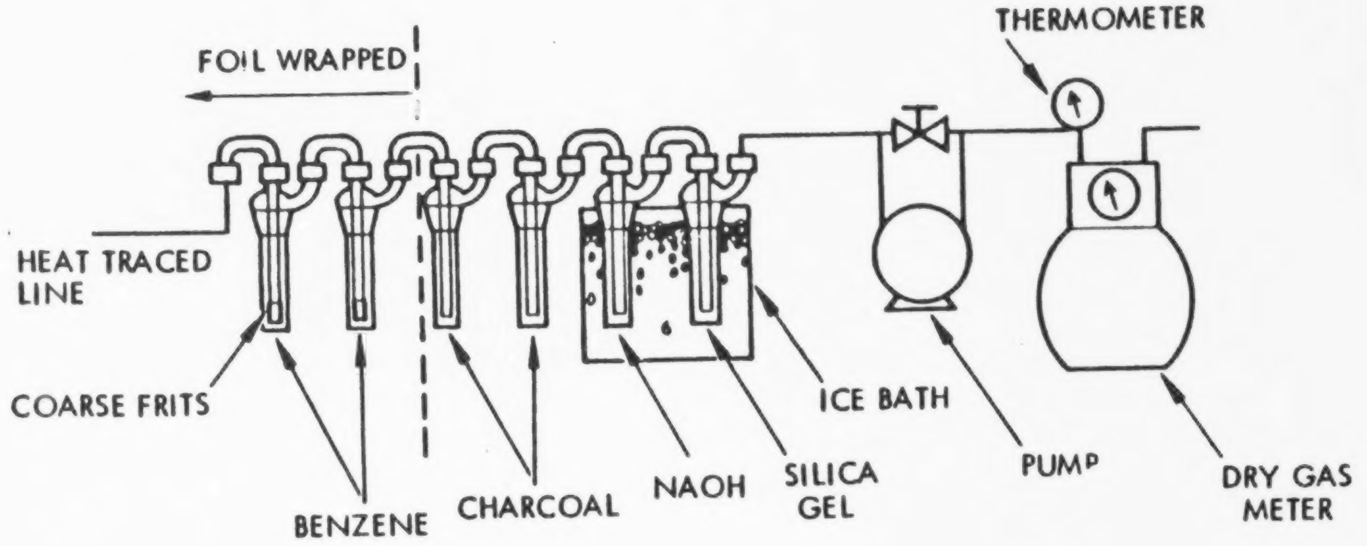

THERMOMETER
FOIL WRAPPED
HEAT TRACED LINE
COARSE FRITS
BENZENE
CHARCOAL
NAOH
SILICA GEL
ICE BATH
PUMP
DRY GAS METER

Figure 4. Schematic of benzene impinger sampling train.

- Wipe samples - Whatman 41 filter paper will be used to wipe selected areas of the ship.
- Miscellaneous sampling - Samples of the fuel, composite waste feed, burner head residue, ship's water, and any other sample deemed necessary for completeness will be taken as needed.

Samples will be split for onboard and land-based confirmatory analyses.

A background test with the incinerators firing only fuel oil should be performed to validate the sampling activities. Sufficient blank samples should also be prepared in accordance with a written quality assurance plan.

4.3.4.3 Analysis Plan--

Onboard analysis--A containerized assembly can be prepared and secured to the ship's deck for monitoring the test burns. A standard shipping container was modified to house the on-line monitoring instrumentation and to serve as laboratory and operations room for the sampling team on the Herbicide Orange project. Its overall dimensions were 2.4 x 6.0 x 2.4 meters. One end had a full width double door with heavy hinges, truck type locking mechanism, and ample weather stripping. A gas conditioning unit was mounted on this door, but ingress and egress were not hindered. A standard 0.8-m door was situated on the inboard side which provided the main entrance and exit. On the same side and in the middle of the container, there was a window which could serve as an emergency exit. The total weight of the equipment and container was about 9,100 kg. The container could be forklifted or hoisted by slings and was structually sound for stacking. The equipment container was stacked above an identical container which was used for storage of supplies and spares.

Onboard analysis of samples for PCB will be performed using a gas chromatograph (GC) with electron capture detector (ECD). A detection limit of approximately 0.2 mg PCB/m^3 for stack samples, and 0.1 mg/m^3 for ambient air samples is expected. These detection limits should be adequate from both a technical and a safety standpoint (See Appendix B for detection limit determinations).

Because PCB wastes are composed of a mixture of PCB isomers, specific procedures for quantitating PCB concentration should be developed. It is recommended that chromatogram peak areas corresponding to selected PCB isomers be determined by an onboard peak integrator. The total area, or the areas of selected major peaks, could then be translated into a PCB concentration (for ambient air), or could be compared to the peak pattern of the waste being burned (to determine destruction efficiency). Onboard PCB analyses will be performed on all samples listed in Section 4.3.4.2.

If permit conditions require onboard analysis for total organic chlorine, a GC with Hall electroconductivity detector should be used. Some GC instruments can be equipped with both the ECD detector (for PCBs) and the Hall detector (for chlorinated organics). If chlorinated organics are to be measured, special studies should be undertaken to adapt the GC/Hall detector technique to at-sea analyses.

Land-Based analyses--Land-based analysis of samples obtained during the incineration of PCBs should be used to confirm the validity of onboard analyses and to characterize more completely incinerator emissions. High resolution gas chromatography/mass spectrometry (GC/MS) techniques are applicable to determination of PCBs and other toxic combustion products. Limited analyses for chlorinated dioxins and dibenzofurans should be considered, because these extremely toxic compounds may be formed from the combustion of PCB wastes containing chlorobenzenes (see Section 4.3.7).

4.3.5 Personnel Safety

Appendix B is a detailed plan for ensuring the health and safety of shipboard personnel during the incineration of liquid PCBs. This plan was adapted from that used onboard the Vulcanus during the incineration of Herbicide Orange (28). This section summarizes Appendix B. In essence, the health and safety plan uses the boundary isolation concept to control the spread of PCB-contaminated wastes. Certain areas (e.g., dining room, galley, living quarters) are designated as clean areas. Other areas (e.g., pump room, main deck, incinerator room) are designated as contaminated. Boundaries are established between these areas, and means of removing contamination are provided at the boundaries to prevent clean areas from becoming contaminated. Procedures are established in the plan to ensure that the plan is being followed.

A Safety Director for at-sea incineration operations will be designated to assist in establishing and maintaining safety procedures and routines. He will be a member of the sampling and monitoring team and his duties will include: 1) safety procedure briefing of all team and ship's personnel; 2) monitoring the implementation of this safety plan; and 3) advising the Team Leader, and ship's Master regarding corrective action for unsafe conditions or incidents.

The Team Leader, acting on behalf of the EPA, shall retain the authority to interrupt and/or initiate incineration. The criteria that will be used by the Team Leader to measure safe shipboard operations are:

- Plume impingement
- PCB spills
- Combustion efficiency
- Onboard determination of PCBs in stack gas
- Onboard determination of ambient levels of PCB

These criteria will only be used as guidelines. In addition to the Team Leader, authority to interrupt or terminate any individual incineration test will also rest with the captain of the Vulcanus. The shore-based Test Director will normally be consulted prior to interruption of a burn.

All personnel will be furnished with safety equipment and issued disposable coveralls to be worn during set-up, operation, and cleanup of all samping and/or monitoring equipment.

PCBs in the work environment can enter the body through the mouth, through the skin, or through the nose and eyes. Thus, eating, drinking, and smoking in working areas; wearing contaminated clothes, leaving liquids on the skin; failure to shower frequently, especially immediately after exposure; and breathing contaminated air must be avoided.

Good personel hygiene practices are of prime importance in preventing exposure of personnel to materials containing PCB. Of comparable importance is the establishment of "clean" areas. The basic requirements for effective personnel hygiene are:

- Protection of personnel from vapor and liquid contact in the contaminated areas by source control and protection gear

- Provision of disposable clothing and foot covers
- Provision of disposal facilities at the interface region between the contaminated and clean areas
- Provision for shower, hand, face, and eye-washing facilities at the interface region
- Provision of clean clothing and foot covering at the boundary of the clean area upon return to working areas
- Instruction in the use of the cleaning equipment and protective equipment and in methods of personal cleansing
- Mandatory and enforced use of the above facilities and concepts

A monitoring system for ensuring the cleanliness of areas such as the galley, mess room, living quarters, bridge, toilets, and passageways, should be put into effect on a firm basis. A schedule of inspection of the clean areas should be established and the results made known to the ship's Master. The safety of all shipboard personnel will have top priority during the incineration of liquid PCBs onboard the Vulcanus.

4.3.6 Contingencies

The ship's Master is in complete command of the vessel at sea. His actions will be consistent with good seamanship and safe navigational practices and in accordance with permit requirements. Operational control should rest with the appropriate Coast Guard District in conjunction with EPA.

4.3.6.1 Notification--

The ship's Master will notify immediately the appropriate government agencies in the event of a casualty or spill. The appropriate Coast Guard District and EPA Regional Office also will be notified. Additionally, the ship's Master will file a report of any incident affecting the ability of the ship to maintain its scheduled course, speed, or location.

The notification and report will provide sufficient information to give interested parties a good understanding of the situation, e.g., nature of casualty, extent of damage or personal injury immediately apparent, course, extent to which operation is impaired, any action being taken to correct or alleviate the situation, and any assistance required.

4.3.6.2 Countermeasures and Assistance--

In the event of fire, collision, grounding, substantial weather damage, or machinery failure, assistance will be initiated and provided in accordance with the National Search and Rescue Plan (NSRP). If necessary, EPA and Coast Guard will obtain salvage services and assist in any other way possible.

The ship's Master will submit situation casualty reports are required until the casualty is corrected. These reports will be addressed to the agencies/parties receiving the intital report.

In emergency situations when immediate removal of the cargo is necessary to save the crew and/or the ship, consistent with the Master's usual authority, he will take action he deems appropriate, including burning or jettisoning. If time and circumstances permit, this action should be coordinated with the appropriate authorities.

In the event of a spill, the ship's Master is responsible for initiating standard damage control measures. He will attempt to contain or limit the extent of the spill using all resources available onboard the vessel.

In non-emergency situations, spill containment, prevention, and clean-up countermeasures described in the Health and Safety Plan (Appendix B) will be followed.

4.3.7 Special Considerations for Incineration of PCBs

4.3.7.1 Regulatory Considerations--

While authority to regulate at-sea incineration is delegated to EPA under the authority of MPRSA and the London Dumping Convention, other statutes and regulations are applicable to incineration of hazardous and toxic wastes. PCB Regulations under TSCA and hazardous waste regulations under RCRA also prescribe requirements for incineration. The TSCA and RCRA requirements, specifically for destruction efficiency, are more stringent than IMCO requirements. Even though the IMCO/MPRSA regulations supercede the TSCA and RCRA regulations for incineration operations at sea, TSCA and RCRA requirements may be considered in the permitting process. In this regard, it is important to note that previous experience with incineration of toxic wastes on the Vulcanus has demonstrated that destruction efficiencies well above those required by IMCO are routinely attained.

4.3.7.2 Technical and Safety Considerations--

Formation of toxic combustion by-products--Incomplete combustion of PCB wastes can give rise to extremely toxic chlorinated organic compounds. Chlorinated dibenzofurans can be formed from PCBs, and chlorinated dioxins can be formed from chlorobenzenes (which are often present in PCB transformer fluids) (29). The at-sea sampling and land-based analysis plans for this project should provide for quantitation of these compounds in a limited number of stack and ambient samples. Such sampling and analysis is necessary so that an adequate assessment can be made of the safety of at-sea incineration of PCBs.

Waste feed rates--Waste feed rate is a critical parameter in at-sea incineration operations. Maximum and sometimes minimum waste feed rates have been specified in previous ocean dumping permits. Three major factors which can act as constraints to waste feed rates are:

- Burner specifications
- Safety considerations
- Waste heating value and PCB content

Ultimately, the waste feed rate determines the duration of the burn. Therefore, waste is fired at the highest rate possible consistent with regulatory, technical, and safety considerations.

For incineration of PCBs on the Vulcanus, burner specifications limit the range of feed rates to between about 5 metric tons (mt) per hour (based on a 5:1 turndown ratio, Section 4.3.3.3) and 25 mt/hr. Safety considerations based on calculations presented in Appendix B will dictate a maximum feed rate of PCBs. Finally, waste heating value must be known to establish the maximum feed rate which does not degrade refractories in the combustor and the minimum feed rate needed to sustain stable combustion at the required temperature.

In Appendix B, calculations were performed to determine a maximum PCB feed rate which was consistent with maintaining safe working levels of PCB in the air aboard ship. Conservative assumptions were made as to PCB destruction efficiency (99.9 percent) and combustion effluent flow rate (70,000 m^3/hr). A maximum allowable PCB concentration in the stack of 5 mg/m^3 was assumed, based on the fact that combustion gases would be diluted at least 1000:1 and result in a PCB concentration on deck of less than one-hundreth of the Threshold Limit Value (TLV). Maximum allowable feed rate of PCB (not PCB fluids) was calculated to be 0.70 mt/hr (both incinerators). Actual waste feed rate (r_w) would be related to the average weight percent of PCB in the waste (f) by the following expression:

$$r_w = \frac{0.70}{f} \times 100$$

Using the minimum r_w in the above equation would enable calculation of a maximum allowable PCB concentration in the waste. The minimum r_w based on burner specifications is 5 mt/hr, therefore, the maximum allowable PCB content of the waste is 14%.

Several caveats are necessary in interpreting the results of this calculation. First, it is assumed that the Vulcanus burners can turn down to a 5 mt/hr feed rate and still achieve stable combustion conditions above 1250°C. Second, the assumptions used to calculate the maximum PCB feed rate, particularly the destruction efficiency assumed, have a tremendous bearing on the result. Should destruction efficiencies greatly exceed 99.9 percent, as expected, safety considerations may not be significant in determining waste feed rates. Finally, the available PCBs are not sufficiently characterized in terms of heat content and PCB concentration to accurately determine acceptable waste feed rates.

4.4 CARGO TANK DECONTAMINATION

Two cargo tank decontamination procedures are described in this section. The first is a recommended procedure in which the level of residual PCBs in the cargo tanks is reduced by incinerating wastes in a particular sequence based on their PCB content. A special procedure is also described as a contingency in the event of a casualty or other occurance requiring manual repairs inside the cargo tanks.

4.4.1 Recommended Procedure

Serial rinsing of the ship's tanks using successively lower concentration PCB wastes is the recommended procedure for cargo tank decontamination. That is, after a tankful of high concentration PCB liquids has been incinerated, the tank should be filled again with lower concentration PCB liquids which are then incinerated. This procedure should provide sufficient removal of residual PCBs. Full decontamination using a triple rinse or equivalent procedure is unnecessary because PCB residues remaining in the tanks will be greatly diluted by subsequent waste cargoes and destroyed during ensuing burns.

During this cleaning operation , no monitoring in addition to that performed during normal incineration operations is necessary. After all PCBs have been incinerated, samples of the main deck surfaces should be taken and analyzed for PCB content. This was one of the procedures used to examine the Vulcanus after Herbicide Orange incineration. Acquisition of samples of tank residuals and rust may be considered if these samples can be obtained without undue exposure of the sampling crew to PCBs.

Tank decontamination operations impose no personnel health and safety requirements above those presented in Appendix B and summarized in Section 4.3.5. The health and safety plan will remain in effect during tank decontamination operations to ensure, for example, that no PCBs are tracked into the clean areas of the ship.

4.4.2 Special Decontamination Procedures

Normally, the tanks on the Vulcanus are not cleaned between burns of different wastes, because no humans are exposed to waste residues inside the empty tanks. However, if entry into the cargo tanks is required after PCBs are burned, a tank decontamination procedure more rigorous than that recommended in Section 4.4.1 should be employed.

A situation such as this arose after incineration of Herbicide Orange. Immediately after the Herbicide Orange burns, the Vulcanus was scheduled for dry dock maintenance. This maintenance required that personnel enter the cargo tanks and perform welding operations. Because the tanks contained residual herbicide, thorough decontamination of the tanks was required before the ship could enter port. Agreements were made between the U.S. and other governments regarding acceptable limits in tank residuals of the dioxin contaminant in the herbicide. EPA-approved procedures were utilized to decontaminate the ship's tanks at sea.

Tank decontamination procedures and acceptable PCB concentrations in tank residues should be stated in contingency plans. The decontamination procedure employed should be tailored to the specific situation using the most applicable equipment and procedures. Acceptable levels of PCBs in tank residuals should also be determined based on the situation. Because TSCA regulations have set the lower limit concentration for regulating PCBs at 50 ppm, verification of residual PCB levels in the ship's tanks of less than 50 ppm should be required.* However, health and safety considerations may require a more stringent criterion. For example, if welding or cutting torches must be used on the tanks, consideration should be given to the possible thermal formation of noxious compounds from heating residual PCBs in the tanks.

---

* A recent court decision on the 50 ppm limit (described in the May 20, 1981 Federal Register) may affect this criterion.

5. LOGIC NETWORK AND SCHEDULE

A preliminary logic network and schedule for a project to dispose of government-owned PCB wastes are presented in this section. Several assumptions have been made in constructing the logic network and project schedule. These assumptions involve estimating durations and assuming certain logical relationships between tasks. The major logical assumptions were as follows:

- EPA would coordinate collection and transportation of PCB wastes to a central land-based processing facility, requiring contracts with individual waste owners.
- The ship owner would also operate the land-based processing facility, so that a single contract could be awarded for land-based and at-sea operations.
- An incinerator ship would be certified, in U.S. waters, and available to incinerate PCBs when required.
- No permits other than an ocean dumping permit would be required.
- A designated ocean incineration site would be available for the project.

Because monitoring activities on land and at sea were not anticipated to be critical schedule items, they were not included in the preliminary schedule. Planning and performance of these tasks are, however, essential from a project standpoint.

5.1 CRITICAL PATH MODEL

Figure 5 is a critical path model, or logic network, for the PCB disposal project. This skeleton network shows major program tasks, their logical interrelationships, and approximate durations as they are currently envisioned. Results of the critical path analysis indicate a total project duration, from decision to proceed with disposal to incineration at sea, of about 10 months. Activities along the critical path are as follows:

- Obtain contracts with ship owner and waste owners
- Ship wastes to land based facility
- Receive and analyze wastes at land-based facility

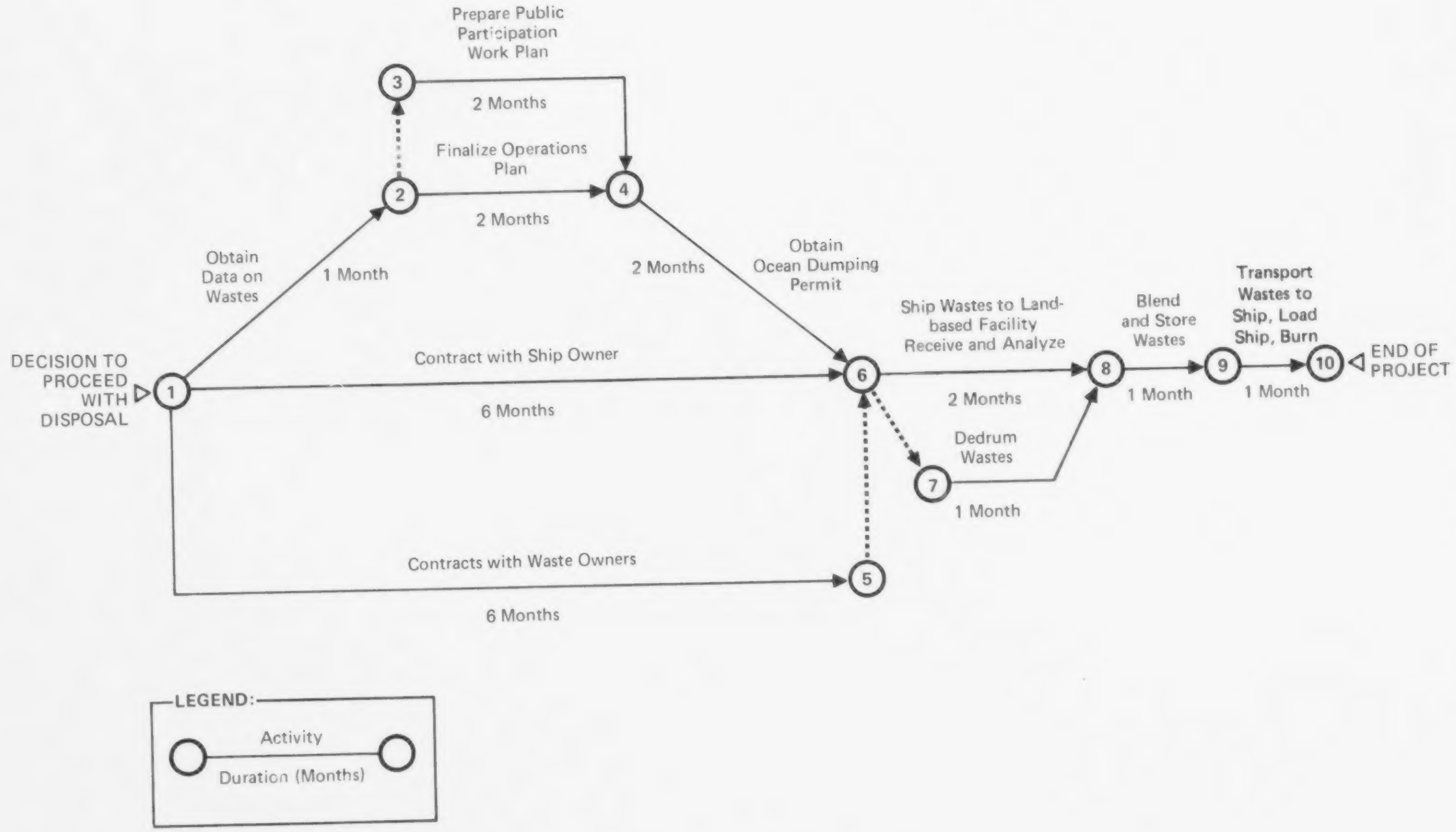

Prepare Public Participation Work Plan
2 Months
Finalize Operations Plan
2 Months
Obtain Data on Wastes
1 Month
2 Months
Obtain Ocean Dumping Permit
DECISION TO PROCEED WITH DISPOSAL
Contract with Ship Owner
6 Months
Ship Wastes to Land-based Facility Receive and Analyze
2 Months
Dedrum Wastes
1 Month
Blend and Store Wastes
1 Month
Transport Wastes to Ship, Load Ship, Burn
1 Month
END OF PROJECT
Contracts with Waste Owners
6 Months
1
2
3
4
5
6
7
8
9
10
LEGEND:
Activity
Duration (Months)

Figure 5. Skeleton logic network for PCB disposal program.

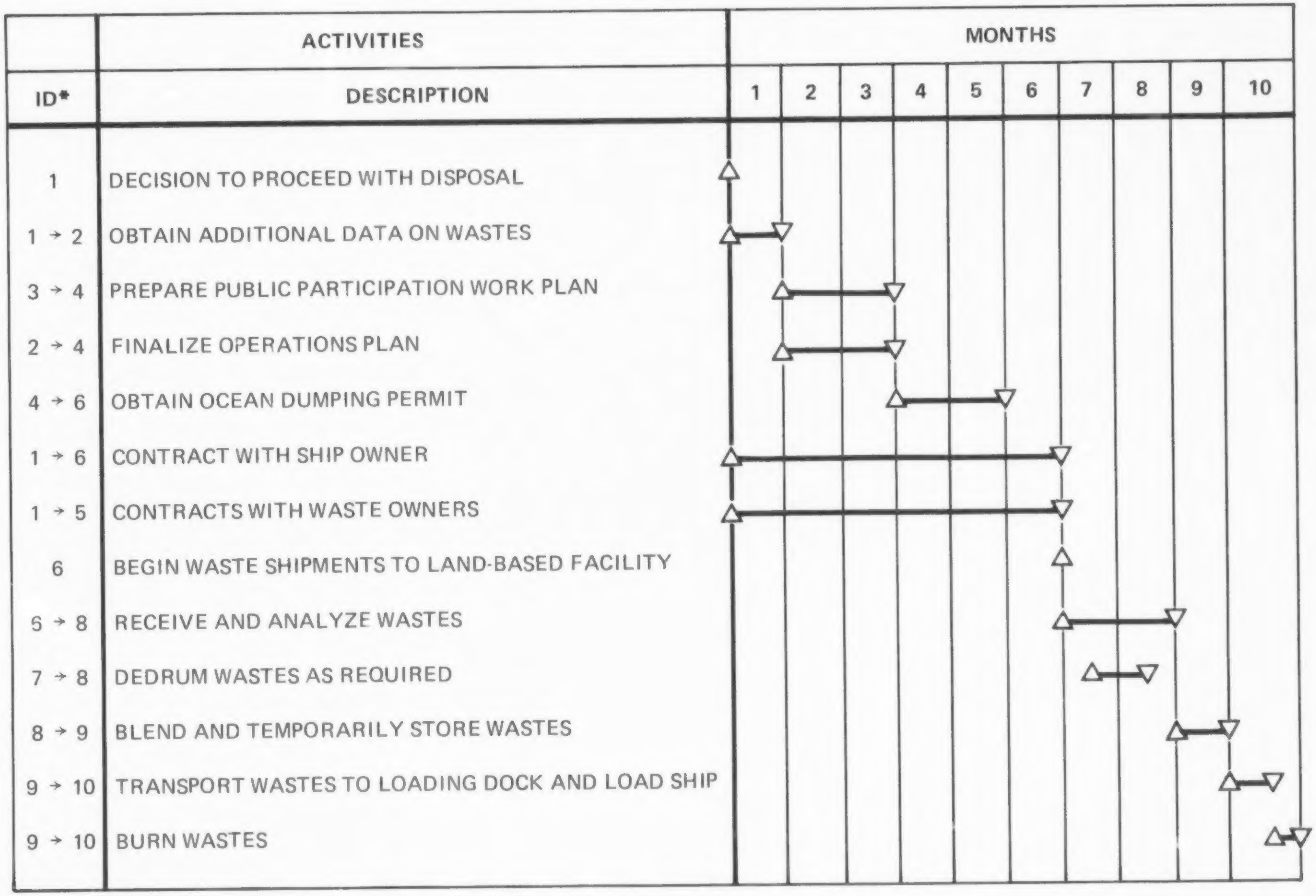
- Blend and temporarily store wastes
- Transport wastes to ship loading dock and load ship
- Incinerate wastes at sea

5.2 SCHEDULE

Logic and schedule information from the critical path model have been incorporated into a bar chart project schedule, Figure 6. The major critical path activities are related to contracts between EPA and the ship owner for disposal services and between EPA and individual waste owners concerning waste transportation (including liability).

Two key milestones are important in performance of this project, in light of the preliminary schedule for incineration. The first is the expiration of the designation of the Gulf Ocean Incineration Site. Designation of this site expired on 15 September 1981. Because this ocean incineration site has been identified as the site for at-sea incineration of PCBs, redesignation of this site will be required. The second important milestone is the expiration of the seaworthiness certificate of the Vulcanus (September 1982). No incineration could take place on the Vulcanus after this date unless the ship's certification were extended temporarily or the ship were recertified.

Based on the current assumptions for project logic and duration, it is possible for EPA to coordinate an at-sea incineration project for disposal of government-owned PCBs on the Vulcanus under the existing ocean dumping permit before the ship's certificate expires. To do this, a decision to proceed with disposal must be made by December 1980. An alternative scenario which might further compress the project schedule would be for individual waste owners to contract directly with the ship owner for disposal services. In either case, the need for obtaining an ocean dumping permit (activity 4-6) would be negated, because a permit already exists. Otherwise, government-owned PCB wastes could not be incinerated at sea until (a) another at-sea incineration vessel becomes available, and (b) another ocean dumping permit is applied for and approved. This alternative would delay substantially the disposal project. This would result in additional costs being incurred by a number of government organizations for storing PCB wastes. Such a delay might force many of these organizations to abandon at-sea incineration for other disposal methods as a means of destroying their liquid PCB wastes.



* Refers to activity numbers on logic network

Figure 6. Project schedule.

REFERENCES

1. Electric Power Research Institute, "Disposal of Polychlorinated Biphenyls (PCBs) and PCB-Contaminated Materials", EPRI Report No. FP-1207, Vol. 1, October 1979.

2. Wastler, T.A., C.K. Offutt, C.K. Fitzsimmons, and P.E. DesRosiers, "Disposal of Organochlorine Wastes by Incineration At Sea", EPA-430/9-75-014, July 1975.

3. Clausen, J.F., H.J. Fisher, R.J. Johnson, E.L. Moon, C. C. Shih, R.F. Tobias, and C.A. Zee, "At-Sea Incineration of Organochlorine Wastes Onboard the M/T. Vulcanus", EPA-600/2-77-196, September 1977.

4. Ackerman, D.G., H.J. Fisher, R.J. Johnson, R.F. Maddalone, B.J. Matthews, E.L. Moon, K.H. Scheyer, C.C. Shih, and R.F. Tobias, "At-Sea Incineration of Herbicide Orange Onboard the M/T. Vulcanus", EPA-600/2-78-086, April 1978.

5. Ackerman, D.G., "Destruction Efficiencies for TCDD During At-Sea Incineration of Herbicide Orange", EPA Contract No. 68-02-2660, March 1979.

6. Thomas, T.J., D.P. Brown, J. Harrington, T. Stanford, L. Taft, and B.W. Vigon, "Land-Based Environmental Monitoring at Johnston Island - Disposal of Herbicide Orange", Report to U.S. Air Force Occupational and Environmental Health Laboratory, Brooks AFB, TX, No. OEHL TR-78-87, September 1978.

7. Young, A.L., J.A. Calcagni, C.E. Thalken, and J.W. Tremblay, "The Toxicology, Environmental Fate, and Human Risk of Herbicide Orange and its Associated Dioxin", Report from U.S. Air Force Occupational and Environmental Health Laboratory, Brooks AFB, TX, No. OEHL TR-78-92. October 1978.

8. Kiefer, I.G. and R.H. Wyer, "Disposal of Herbicide Orange", EPA Draft Report, April 1979.

9. Report of the Interagency Ad Hoc Work Group for the Chemical Waste Incinerator Ship Program, U.S. EPA, U.S. Dept. Commerce, U.S. DOT, Sept., 1980.

10. Thomas, T.J., et al. Land-Based Environmental Monitoring at Johnston Island-Disposal of Herbicide Orange. Prepared for U.S. Air Force Occupational and Environmental Health Laboratory by Battelle Columbus Laboratories, Columbus, Ohio, Sept., 1978.

11. Ackerman, D.G., et al. Operations Plan and Guidelines for the At-Sea Incineration of Liquid Silvex. Prepared by TRW for U.S. EPA, March 1980.

12. Polychlorinated Biphenyls-Ambient Water Quality Criteria. Criteria and Standards Division, Office of Water Planning and Standards, U.S. Environmental Protection Agency, Washington, D.C., NTIS #PB 296803.

13. Ackerman, D.G., et al. At-Sea Incineration of Herbicide Orange Onboard the M/T Vulcanus. EPA-600/2-78-086. April 1978.

14. Huibregtse, K.R., et al. Manual for the Control of Hazardous Material Spills, Vol. I. Spill Assessment and Water Treatment Techniques. EPA-600/2-77-277, November 1977.

15. U.S. Dept. of the Air Force, Final Environmental Impact Statement, Disposition of Orange Herbicide by Incineration, November 1974.

16. U.S. Air Force Logistics Command, Contingency Plan for Ocean Incineration of Herbicide Orange. San Antonio ALC, April 1977.

17. Air Force Logistics Command, Programming Plan 75-19 for the Disposal of Orange Herbicide. San Antonio ALC, April 1977.

18. U.S. Dept. of Health and Human Services, 1979 Registry of Toxic Effects of Chemical Substances, R.J. Lewis and R.L. Tatken, eds. Sept. 1980.

19. Ackerman, D.G., et al. Guidelines for the Disposal of PCBs and PCB Items by Thermal Destruction. Draft report prepared by TRW for U.S. EPA, May 1980.

20. Federal Register 44(169):50766-50786. August 29, 1979.

21. Preliminary Survey of Existing Maritime Terminal Facilities on Continental United States Atlantic, Gulf and West Coasts which have Capabilities of Serving an At-Sea Incineration Ship. TRW, 1980.

22. Electric Power Research Institute. Disposal of Polychlorinated Biphenyls (PCBs) and PCB-Contaminated Materials. Volume 2: Suggested Procedures for Development of PCB Spill Prevention Control and Countermeasure Plans, EPRI FP-1207, Vol. 2, Oct. 1979.

23. Zelenski, S.G., J. Hall, and S.E. Haupt. Applying for a Permit to Destroy PCB Waste Oil, Volume I, Summary. EPA-600/2-81-033a, March 1981.

24. U.S. Environmental Protection Agency, Final Environmental Impact Statement, "Designation of a Site in the Gulf of Mexico for Incineration of Chemical Wastes", July 1976.

25. U.S. Environmental Protection Agency, Draft Environmental Impact Statement on the North Atlantic Incineration Site, 1979.

26. U.S. Environmental Protection Agency, Ocean Dumping Regulations, Research Permit No. 770DH001R and Special Permit No. 770DH001S.

27. Ackerman, D.G., R.J. Johnson, E.L. Moon, A.E. Samsonov, and K.H. Scheyer, "At-Sea Incineration" Evaluation of Waste Flow and Combustion Gas Monitoring Instrumentation Onboard the M/T. Vulcanus", EPA-600/2-79-137, July 1979.

28. "Safety Plan for Incineration of Herbicide Orange Onboard the M/T Vulcanus", TRW Report to EPA, May 1977.

29. Rappe, C. and H.R. Buser, "Formation and Degradation of Polychlorinated Dibenzo-p-dioxins (PCDDs) and Dibenzofurans (PCDFs) by Thermal Processes", paper presented at 178th National American Chemical Society Meeting, Washington, D.C., September 9-14, 1979.

APPENDIX A

INVENTORY OF PCB STOCKS

This appendix contains specific information obtained from individuals responsible for the disposal of government-owned PCB wastes (Sections A-1 through A-7). This information supplements data presented in Section 2 of this report. Additional information from three private industry contacts is presented in Sections A-8 through A-10. Quantities, locations, and descriptions of available and potentially available PCB stocks are included.*

Disposal cost and timing are two of the key variables which determine the amount of PCBs in this inventory which will actually be available for at-sea incineration. For several organizations, willingness to use at-sea incineration (as opposed to land-based alternatives) will depend on the total cost of disposal. Other organizations are investigating land-based disposal methods for both cost and timing considerations.

For incineration of PCB fluids, total disposal cost consists of two elements: transportation cost and incineration cost. Transportation costs for hazardous wastes (by truck) are approximately $3.00 per mile plus a 15 to 19 percent fuel surcharge (1). Costs for land-based incineration of PCBs vary widely, depending on the nature of the waste (e.g., sludge content). A recently published price list from one land-based incineration firm quotes the following prices for disposal of PCB liquids containing less than 5% sludge (2): $0.50 per pound for materials in bulk (greater than 20,000 pounds) and $500 per drum (greater than 25 drums). Costs for at-sea incineration of PCBs are difficult to estimate, because these types of waste have never been disposed of in this manner. However, for organochlorine liquids in general, it has been estimated that at-sea incineration is less expensive than land-based incineration (3).

---

*See Section 2 of this report for a definition of the terms "available" and "potentially available" as they are used in this report.

Timing is also considered important for many of the organizations contacted for this inventory. In some cases, organizations interested in at-sea incineration could not continue storing wastes for such a project if it would not be accomplished until late 1981. These organizations contracted for land-based disposal services, and their wastes are not reported in the inventory. Other organizations, while still considering at-sea incineration as a disposal method, have initiated inquiries to and/or negotiations with land-based disposal firms. Wastes from these organizations are reported in the inventory as available, but availability is contingent on timely inception of an at-sea incineration project.

The following sections present data on PCB waste stocks obtained from verbal and written contacts with responsible individuals in each organization. These data are current as of approximately September 1981.

A-1. GOVERNMENT ORGANIZATION #1

This organization has available 10,000 gallons of PCBs in three warehouses in the Washington, D.C. area. An additional 55,000 gallons of PCB fluids are potentially available through this organization from accelerated transfer of fluids from transformers and from other Federal agencies in the Washington area. Substantially more PCB transformer fluids are still in service than are out of service. The total quantity is about 250,000 gallons which will be removed over the next 10-20 years. Approximately 3,000 gallons of PCB fluids from this organization were disposed of by land-based incineration (no price given), but at-sea incineration is still being considered for disposal of remaining waste stocks. Table A-1 shows site locations, waste composition, and applicable transportation modes for these wastes. This organization does not have a regular transportation contractor. The contact person indicated that one would be selected on a competitive basis.

A-2. GOVERNMENT ORGANIZATION #2

This organization is responsible for disposal of 21,500 gallons of PCB fluids which are considered available. No potentially available stocks were identified. The location and composition of the available stocks are shown in Table A-2. The PCBs in Alabama may be incinerated on land, but a schedule

TABLE A-1. PCB STOCKS FROM GOVERNMENT ORGANIZATION #1

Storage site locations	Stock descriptions	Storage container descriptions	Transportation information
Washington, D.C. Area #1	Amount: Approximately 4,000 gallons. Description: Transformer fluids, some kerosene and Varsol rinsate. No sludge, small amount of water cover in a few of the barrels. 100% pumpable.	All stocks stored in 55 gallon drums. None are leaking, some are overpacked.	Truck transport only.
Washington, D.C. Area #2	Amount: Approximately 3,000 gallons. Description: Same as above.	Same as above.	Truck transport only.
Washington, D.C. Area #3	Amount: Approximately 3,000 gallons. Description: Same as above.	Same as above.	Truck and rail transport available.

TABLE A-2. PCB STOCKS FROM GOVERNMENT ORGANIZATIONS #2

Storage site locations	Stock descriptions	Storage container descriptions	Transportation information
Alabama	Amount: Approximately 20,000 gallons. Description: Transformer oil, 100% pumpable.	All stocks stored in 6E and 17E 55 gallon drums, good to excellent condition.	Rail and truck transport available.
New York	Amount: Approximately 2,000 gallons. Description: Arochlor 1260 in sludge with activated carbon and kerosene. 75% pumpable.	Same as above.	Truck transport only.

for this is highly uncertain. Until this schedule is defined and funding is obtained, at-sea incineration is still being considered as a disposal method.

A-3. GOVERNMENT ORGANIZATION #3

This organization owns 20,000 gallons of PCB fluids which are considered available for at-sea incineration. No potentially available PCBs were identified. The contact person was very willing to help locate additional PCB wastes from private- and publicly-owned utilities. The available PCBs are stored in Alabama. They consist of a mixture of transformer fluid, pure PCB, and rinsates (solvents, mineral spirits). Concentrations of PCB range from 50% to 100%. Little or no water is present in the stocks. They are nearly 100% pumpable (very little sludge). All stocks are stored in 55-gallon drums (477 drums total). Truck and rail transport are applicable. An estimate of $500 per drum was quoted to the responsible official in this organization by a representative of a land-based incineration firm for disposal of these PCBs.

A-4. GOVERNMENT ORGANIZATION #4

The total quantity of available PCB fluids from this organization is 271,800 gallons. An additional 628,000 gallons are still in transformers, hydraulic systems, and lubricating systems and are considered potentially available. Site locations and waste compositions are shown in Table A-3. Some volumes reported in the table were obtained by assuming an approximate density of 13 pounds per gallon for transformer fluids and 10 pounds per gallon for waste oils. These approximations were obtained from a contact within this organization.

A-5. GOVERNMENT ORGANIZATION #5

PCB stocks owned by this organization are stored at three GOCO (government-owned, contractor operated) facilities. The total quantity of available PCB fluids from all three facilities is 41,700 gallons. Potentially available PCB fluids total about 24,000 gallons. Because of the nature of the ownership of these wastes, responsible officials at two of the GOCO facilities were especially concerned as to their liability in any EPA sponsored disposal project, once wastes had left their facility.

TABLE A-3. PCB STOCKS FROM GOVERNMENT ORGANIZATION #4

Storage site locations	Stock descriptions	Storage container descriptions	Transportation information
Tennessee #1	Bulk storage. Amount: Approximately 160,000 gallons. Description: 70 ppm PCB in mineral oil.	One 120,000 gallon storage tank, two 20,000 gallon storage tanks.	Truck and rail transport available.
	Bulk storage. Amount: Approximately 8,000 gallons. Description: 700 ppm PCB in waste oils.	One storage tank.	Same as above.
	Bulk storage. Amount: Approximately 6,000 gallons. Description: 1,000 ppm PCB in waste oils.	One storage tank.	Same as above.
	Bulk storage. Amount: Approximately 20,000 gallons. Description: 2,500 ppm PCB in waste oils.	One storage tank.	Same as above.
	Transformers. Amount: 55,550 gallons. Description: Fluids not yet removed from transformers.	92 units.	Same as above.
	Hydraulic systems. Amount: 1,300 gallons. Description: PCB concentration ranges from 125 to 16,000 ppm. Fluids are not yet removed from the hydraulic systems.	6 units.	Same as above.
Tennessee #2	Drum storage. Amount: Approximately 10,600 gallons. Description: Waste oils, kerosene rinsate, and other unspecified wastes. PCB concentration >500 ppm.	Stored in 55 gallon drums.	Truck and rail transport available.

(continued)

TABLE A-3. CONTINUED

Storage site locations	Stock descriptions	Storage container descriptions	Transportation information
	Drum storage. Amount: Approximately 2,000 gallons. Description: Waste oils, kerosene rinsate, and other unspecified wastes. PCB concentration >50 ppm.	Stored in 55 gallon drums.	Same as above.
	Bulk storage. Amount: Approximately 12,000 gallons. Description: Transformer fluids.	Stored in two storage tanks.	Same as above.
	Transformers. Amount: Approximately 119,000 gallons. Description: Fluids not yet removed from transformers.	84 units.	Same as above.
Tennessee #3	Transformers. Amount: Approximately 6,000 gallons. Description: Fluids not yet removed from transformers.	15 units.	Truck transport only.
	Hydraulic systems. Amount: Approximately 7,300 gallons. Description: Fluids not removed from systems. PCB concentration ranges from 90-300 ppm.	4 units.	Same as above.
Kentucky	Bulk storage. Amount: Approximately 11,200 gallons. Description: Transformer fluids.	Two storage tanks.	Truck and rail transport available.
	Transformers. Amount: Approximately 105,000 gallons. Description: Fluids not yet removed from transformers.	90 units.	Same as above.

(continued)

TABLE A-3. CONTINUED

Storage site locations	Stock descriptions	Storage container descriptions	Transportation information
Ohio	Lubricating systems. Amount: Approximately 23,000 gallons. Description: Lubricating oil not yet removed from systems. PCB concentration 75 ppm.	1 unit.	Same as above.
	Hydraulic systems. Amount: 500 gallons. Description: 1.5-5.0% PCB.	5 units.	Same as above.
	Drum storage. Amount: Approximately 100 gallons. Description: Waste oils, PCB concentration >500 ppm.	Stored in 55 gallon drums.	Rail and truck transport available.
	Bulk and drum storage. Amount: Approximately 42,300 gallons. Description: Transformer fluid (Pyranol).	Two storage tanks and approximately 200 drums.	Same as above
	Transformers. Amount: Approximately 161,000 gallons. Description: Fluids not yet removed from transformers.	133 units.	Same as above.
	Lubricating systems. Amount: Approximately 150,000 gallons. Description: Lubricating oil not yet removed from systems. PCB concentration ranges from 80 to 250 ppm.	8 units.	Same as above.

Table A-4 summarizes the location and composition information obtained for these stocks. Disposal of the stocks in New Mexico and Colorado by land-based incineration is being considered, however, at-sea incineration has not been ruled out. The responsible official at the New Mexico facility quoted a rough estimate for land-based incineration of these stocks at $750 per drum, not including transportation. Only the GOCO organization in Missouri has a regular transportation contractor for waste shipments.

A-6. GOVERNMENT ORGANIZATION #6

This organization is the operator of a publicly-owned municipal utility. The total volume of available PCB fluids from this organization is approximately 60,000 gallons. No potentially available stocks were identified. Available stocks consist of 70 55-gallon drums of transformer fluid (30-40% PCB), and a 30,000 gallon tank of PCB-contaminated #6 (Bunker C) fuel oil. The fuel oil contains 1000 ppm PCB. It is very viscous and would be cut with #2 fuel oil in order to facilitate pumping. With dilution the total volume of both transformer fluid and fuel oil would be about 60,000 gallons.

Cost is the prime consideration in determining availability of these stocks. If the cost to the utility of at-sea incineration would be competitive with land-based disposal alternatives, these wastes would be available. Current estimates for land-based incineration costs range from $200,000 to $300,000, including transportation. A proposal is being evaluated for non-thermal destruction of the PCBs in the contaminated fuel oil. A feasibility study and conceptual design for a non-thermal destruction system has been proposed.

A-7. GOVERNMENT ORGANIZATION #7

This organization has approximately 100,000 gallons of PCB transformer fluids plus about 40,000 gallons of rinsate for a total of 140,000 gallons of waste stocks. Site locations are nationwide. All stocks are 100% pumpable (no sludge). However, the contact person did not appear to be interested in at-sea incineration as a disposal method for these PCBs. These stocks are therefore considered only potentially available for at-sea incineration. The organization is planning to dispose of their stocks via commercial land-based facilities, and has issued a request for proposals for incineration of at

TABLE A-4. PCB STOCKS FROM GOVERNMENT ORGANIZATION #5

Storage site locations	Stock descriptions	Storage container descriptions	Transportation information
Missouri	Amount: Approximately 35,000 gallons. Description: 40% PCB in Therminol.	55-gallon drums, excellent condition, DOT approved. Some overpacked.	Truck transport only.
New Mexico	Drum storage. Amount: Approximately 5,500 gallons. Description: Transformer fluids. (Available)	55-gallon drums.	Truck transport only.
	Drum storage. Amount: Approximately 4,600 gallons. Description: Transformer fluids. (Potentially available)	55-gallon drums.	Same as above.
	Transformers. Amount: Approximately 11,000 gallons. Description: Fluids not yet removed from transformers.	Number of units not available.	Same as above.
Colorado	Drum storage. Amount: Approximately 1,200 gallons. Description: Transformer fluids.	55-gallon drums.	Truck transport only.
	Transformers. Amount: Approximately 8,800 gallons. Description: Fluids not yet removed from transformers.	20 units.	Same as above.

least one-third of the total national stocks. In general, the contact in this organization has been reluctant to provide information.

A-8. PRIVATE INDUSTRY CONTACT #1

The total quantity of PCBs available for at-sea incineration from this source is up to 750,000 gallons. Some of these wastes may be incinerated under the current ocean dumping permit. This firm handles PCB waste storage and disposal operations for industrial clients. Wastes are currently available from clients in four states: Michigan, Maryland, Pennsylvania, and New Jersey. These wastes are all askarel (transformer fluid) concentrates. Much of the waste is stored in drums. These wastes could be loaded and shipped within 180 days of notification to proceed.

Cost is the major factor in determining the availability of these stocks. The cost to this firm (and/or its customers) would have to be less than or equal to the costs of land-based incineration for these stocks to be available.

A-9. PRIVATE INDUSTRY CONTACT #2

This firm is storing 40,000 gallons of transformer and capacitor fluids (average 30-40% PCB) for its customers. Another 80,000 gallons is potentially available from other customers; however, the firm is not currently accepting additional PCBs for storage. The storage site is -ocated in the Canadian province of Ontario.

Because there is currently no way for this firm to dispose of its PCBs in Canada, they are interested in participating in this project. However, a major problem exists because the U.S.-Canada border is now closed to shipment of PCBs in either direction. If the border were opened for shipment of these wastes, they would be considered available.

A-10. PRIVATE INDUSTRY CONTACT #3

This firm is storing approximately 840 55-gallon drums (46,000 gallons) of liquid PCBs for industrial clients in the Canadian province of Alberta. The wastes could be shipped to the Gulf coast by truck if the U.S.-Canada border were opened (see private industry contact #2). This firm is still accepting PCBs from clients, so that by early 1982 the amount of available PCBs could easily double.

REFERENCES FOR APPENDIX A

1. Special Report: Competition for PCB Disposal Dollars, New Processes Create New Industries, Prompt a Weighing of Costs, BNA Chemical Regulation Reporter, 5 June 1981, pp 216-218.

2. Price List - Liquid PCBs, Rollins Environmental Services (TX) Inc., 17 February 1981.

3. Shih, C. C., et al. Comparative Cost Analysis and Environmental Assessment for Disposal of Organochlorine Wastes. EPA-600/2-78-190. Prepared for U.S. Environmental Protection Agency by TRW Inc., Redondo Beach, California, August 1978.

APPENDIX B

SAFETY PLAN FOR INCINERATION OF LIQUID PCBs ONBOARD THE M/T VULCANUS

B.1 PURPOSE AND SCOPE

The purpose of this appendix is to define a plan to insure the health and safety of personnel participating in the incineration of liquid PCBs onboard the M/T Vulcanus. All monitoring and ship personnel will adhere to the provisions of this plan during all phases of the incineration. The monitoring leader will brief officers and crew members of the M/T Vulcanus with this safety plan data and procedures. This is particularly important with regard to personal hygiene, equipment malfunctions, spills, and criteria for terminating a given burn. Because of the inherent confinement while at sea and required interaction of the monitoring team and Vulcanus personnel, a thorough understanding of the contents of this document is mandatory on the part of all concerned.

This Safety Plan has been adapted from the plan used for shipboard operations during the at-sea incineration of Herbicide Orange onboard the M/T Vulcanus. The scope of the health and safety plan is limited to shipboard incineration operations. Specifically excluded are the safety requirements for transportation and ship loading operations, which are covered by contractor and M/T Vulcanus procedures.

To assist in establishing and maintaining health and safety procedures and routines, a Safety Director for at-sea incineration operations will be designated. This individual will be a member of the sampling and monitoring team. His duties will include: safety procedure briefing of all ship's personnel; monitoring the implementation of this safety plan; and advising the monitoring team leader, ship's master, and other appropriate personnel regarding corrective action for unsafe conditions or incidents.

B.2 POTENTIAL HAZARDS

Polychlorinated biphenyls (PCBs) are derivatives of the compound biphenyl in which from one to ten of the hydrogen atoms have been replaced with chlorine atoms. PCBs synthesized for commercial use are mixtures of isomers. They are not naturally occurring compounds.

PCBs have extremely high thermal and chemical stability. They are of low volatility (decreases with increasing chlorine content), are relatively nonflammable, and have excellent electrical insulating characteristics. Commercial mixtures are liquids at room temperature. They are insoluble in water, have a low degree of hygroscopicity, and are soluble in most common organic solvents.

Although PCBs have low acute toxicities (Table B-1), other adverse effects have been found in humans, laboratory animals, and other oganisms (3). A summary of toxicological and epidemiological data on the effects of PCBs, adapted from Reference 3 is given below. More detailed discussions are given in References 2 and 3. PCBs appear to cause tumors in laboratory animals. There are limited human epidemiological data, but excess carcinogenic effects have been observed in several large groups of people exposed to PCBs. Several studies in animals have shown that PCBs cause fetal resorption, birth defects, and high offspring mortality rates at levels of 1-5 mg/kg body weight. There is evidence that PCBs produce immunosuppressive effects in laboratory animals. PCBs have been observed to cause liver damage. PCBs have caused chloracne in workers occupationally exposed to air levels as low as 0.1 mg/m^3.

Adverse effects observed in laboratory tests also occur in wild animals. PCBs are known to bioaccumulate and to biomagnify. Effects noted in mink fed PCB contaminated fish include reproductive failure, reduced weight gain, increased mortality, and enlargement of liver, kidneys, and heart.

PCB mixtures are extremely toxic to several species of aquatic invertebrates and fish. Aroclor 1254 is toxic to several shrimp species at levels of about 1 ppb. Increased mortality of sheepshead minnows was observed in water containing 0.16 ppb of Aroclor 1254. Concentrations of Aroclor 1242, 1016, and 1254 as low as 0.1 ppb have been demonstrated to depress photosynthetic activity in phytoplankton.

The Occupational Safety and Health Administration (OSHA), established by the Occupational Safety and Health Act, has set the following standards for occupational exposure to PCBs (4):

TABLE B-1 TOXICITIES OF SELECTED PCB FORMULATIONS

PCB Formulations	Rat, Oral LD_{50}, mg/kg	Rabbit, Skin LD_{Lo}, mg/kg
Aroclor 1221	3980	3169
1232	4470	2000
1242	4250	--
1248	11,000	1269
1254	1295	--
1260	1315	2000
1262	11,300	3160
1268	10,900	2500
2565	6310	3160
4465	16,000	3160

- Chlorodiphenyl (42% chlorine) - TWA of 1 mg/m^3 and STEL of 2 mg/m^3.
- Chlorodiphenyl (54% chlorine) - TWA of 0.5 mg/m^3 and STEL of 1 mg/m^3.

The TWA (Time Weighted Average) is a concentration to which a worker can be exposed for 8-hour days and 40-hour weeks indefinitely without adverse effects. The STEL (Short Term Exposure Limit) is a level to which a worker may not be exposed for more than 15 minutes without suffering adverse effects.

The National Institute of Occupational Safety and Health has proposed an occupational exposure limit to PCBs of 1.0 μg/m^3 on a time weighted average 10-hour day, 40-hour week basis (Natl. Inst. Occup. Safety Health, 1977). Assuming a tidal air volume of 10 m^3 in an eight-hour day and 100 percent absorption, the resulting dose at this exposure level would be 10 μg/day. However, this is a recommendation and is not legally binding. The current legal threshold limit value (TLV) for PCBs as established by the American Conference of Governmental Industrial Hygienists (ACGIH) is 500 μg/m^3 (0.5 mg/m^3).

B.3 CRITERIA FOR INTERRUPTION OF A BURN

The monitoring Team Leader acting on behalf of the U.S. Environmental Protection Agency, shall retain the authority to interrupt incineration operations while the sampling, monitoring team members are onboard the M/T Vulcanus. Furthermore, the Team Leader shall also retain the authority to withdraw team participation in the project at any time during the project if, in his judgement, the conduct of shipboard operations does not meet the safety standards outlined in this plan. The criteria that will be used by the Team Leader to measure safe shipboard operation are summarized in Table B-2 and discussed in the following sections. These criteria will only be used as guidelines, and the final decision for temporary or permanent interruption of any individual incineration test, portion of a particular test, or monitoring participation in the project rests with and is the responsibility of the monitoring Team Leader. It should also be recognized that the decision to terminate any individual incineration test is not the sole responsibility of the monitoring Team Leader. The authority to interrupt any individual incineration test shall also rest with the captain of the M/T Vulcanus. Land-based project personnel will normally be consulted prior to termination of a burn.

B.3.1 Plume Impingement

The plume arising from the incinerator stacks will be injected with ammonia as required to make it visible for tracking. The monitoring Team Leader will direct temporary interruption of an individual burn of liquid PCBs and withdrawal of shipboard personnel to a safe area if, at any time during the test, the plume is observed to have a high probability of descending onto and remaining on the deck of the M/T Vulcanus.

At the temporary interruption of incineration of liquid PCBs, the feedstock to the incinerators will be switched to fuel oil until safe conditions can again be met. If, however, prolonged contact of the plume with the M/T Vulcanus becomes apparent, the furnaces will be shut down until the meterological conditions become more favorable or corrective action has been taken by proper vectoring of the M/T Vulcanus with respect to the wind direction.

TABLE B-2. CRITERIA FOR INTERRUPTION OF INCINERATION OF LIQUID PCBs

Observation/ Measurement	Decision Criteria	Action To Be Taken*
Plume impingement	Plume is observed to have a high probability of descending onto and remaining on the deck of the M/T Vulcanus.	Direct temporary termination of incineration of liquid PCBs and withdrawal of shipboard personnel to a safe area.
Liquid PCB spills	Large spills that cannot be readily contained.	Direct termination of incineration of liquid PCBs and withdrawal of shipboard personnel to a safe area.
Combustion temperature	Temperature drops below the minimum allowable temperature for thermal destruction	Cut-off of waste flow to the burners.
Combustion efficiency	Combustion efficiency less than 99.9%.	Direct termination of incineration of liquid PCBs.
Oxygen	Excess O_2 falls below the required percentage	Cut-off of waste flow to the burners.
Monitoring/recording devices for CO, CO_2, O_2, or PCB	Malfunction of device.	Cut-off of waste flow to the burners.
Onboard determination of PCBs in stack gas	PCB concentration in excess of 5 mg/m^3 in the stack gas.	Direct termination of incineration of liquid PCBs.
Onboard determination of ambient level of PCBs	Ambient (personnel breathing zone) level of PCBs in excess of 0.5 mg/m^3 over 8 hr.	Direct termination of incineration of liquid PCBs and/or immediate withdrawal of shipboard personnel.
Determination of PCBs after each burn	Average destruction efficiency of PCB less than 99.9%.	Direct withdrawal of monitoring participation and recommend against subsequent burns unless corrective action can be taken.
Physical examination of shipboard personnel	Excess PCB exposure in the judgement of the physician.	Direct withdrawal of affected personnel. Evaluate corrective actions if possible to permit continued incineration.

*The monitoring Team Leader will consult with the ship's Master and the U.S. EPA before taking any action to direct termination of a PCB burn. If appropriate, fuel oil may be substituted as a fuel while corrective action is being taken.

B.3.2 Liquid PCB Spills

The monitoring Team Leader will direct termination of any individual burn with liquid PCBs if a spill occurs onboard the M/T Vulcanus that cannot be readily contained.

B.3.3 Combustion Efficiency

The CO and CO_2 levels determined at or near the exit plane of the incinerator stacks will be used as an indication of overall combustion efficiency using the following equation:

$$\%\ \text{Combustion Efficiency} = \frac{CO_2 \text{ concentration}}{CO_2 \text{ concentration} + CO \text{ concentration}} \times 100$$

Combustion efficiencies in excess of 99.9 percent are deemed necessary as an indication that high destruction efficiencies for the liquid PCB constituents may be anticipated. The 99.9 percent combustion efficiency corresponds to approximately 100 ppm CO in the combustion product gas. The high combustion efficiency is required because of the toxic and persistent nature of PCBs. The detection of large amounts of CO in the stack gas (and hence lower combustion efficiency) is a good indication that incomplete mixing is taking place in the incinerator. The monitoring Team Leader will direct termination of any individual burn if the combustion efficiency falls below 99.9 percent and this situation cannot be corrected.

B.3.4 Onboard Determination Of Stack Emissions Of Constituents

In addition to monitoring the CO and CO_2 levels in the stack gas, grab samples collected from the benzene impinger will also be directly injected into a gas chromatograph (GC) equipped with an electron capture detector (ECD). The GC/ECD combination provides a lower detection limit of approximately 0.2 mg/M^3 for PCBs in the stack gas. For onboard safety requirements, the allowable limit for PCB concentration in the stack gas will be 5 mg/M^3. The TLV for Aroclor 1254 is 0.5 mg/M^3. The 5 mg/M^3 limit is selected on the basis that, with atmospheric dispersion, an emission concentration equal to 10 times the TLV would lead to an ambient level concentration of less than 0.01 TLV. For chronic 24-hour exposures of the sampling and ship personnel to PCBs in ambient air, the 0.01 TLV level is considered to be safe.

Assuming 99.9 percent destruction efficiency, a combustion effluent flow rate of 70,000 m^3/hr (dry, 20°C), and a maximum allowable PCB concentration in the stack gas, the maximum PCB input rate per incinerator is:

$$Y \frac{\text{kg}}{\text{hr}} \times 10^6 \frac{\text{mg}}{\text{kg}} \times 0.001 \frac{\text{mg PCB in Stack}}{\text{mg PCB in Feed}} \times \frac{1 \text{ hr}}{70{,}000 \text{ m}^3} = \frac{5 \text{ mg PCB in Stack}}{\text{m}^3}$$

$$Y = 350 \frac{\text{kg}}{\text{hr}} \text{ or } 0.35 \frac{\text{mt}}{\text{hr}} \quad (750 \text{ kg/hr for both incinerators})$$

This represents input rate in terms of mass of PCB, not fluid containing PCB. With dispersion in the atmosphere, the levels of (unburned) PCBs in the living/working areas of the ship should be well below 0.01 TLV (0.005 mg/m^3).

The monitoring Team Leader should consider interrupting any individual burn if the PCB concentration in the stack gas is in excess of 5 mg/M^3.

B.3.5 Onboard Determination Of Ambient Level Of Liquid PCB Constituents

Ambient PCB concentrations result from atmospheric disperson of stack emissions as well as any fugitive emissions onboard the M/T Vulcanus. The monitoring Team Leader will alert shipboard personnel and direct the location and elimination of emission sources if the ambient (personnel breathing zone) level of PCBs in excess of 1.0 mg/M^3. The monitoring Team Leader should consider interrupting any individual burn and/or immediately withdrawing shipboard personnel from a contaminated area if the ambient (personnel breathing zone) level of PCB is in excess of 0.5 mg/M^3 over an 8-hour period.

B.3.6 Determination Of PCB Levels

At completion of each burn, the grab samples collected during the incineration of liquid PCB and the personal monitoring devices will be analyzed for PCB content. The monitoring Team Leader will direct withdrawl of team participation and recommend against subsequent burns if the results of the analysis indicate any of the following: 1) the average destruction efficiency for PCBs with the M/T Vulcanus incinerators is less than 99.9 percent; 2) the average ambient level onboard the M/T Vulcanus is in excess of 0.5 mg/M^3.

At 99.9 percent PCB destruction efficiency, the total amount of PCB emitted is expected to be 700 kg/hr from both incinerators at a total mass feed rate of PCB (not PCB fluid) of 700 kg/hr. With atmospheric dispersion, this level of PCB emission at the stack would lead to a maximum ambient PCB level of about 0.005 mg/m^3, well below the TLV.

B.3.7 Physical Examinations

Because of the potential health hazard related to the incineration of liquid PCBs onboard the M/T Vulcanus, complete physical examinations will be performed on all monitoring team personnel involved in the sampling and monitoring effort. These physical examinations will be conducted on the employee just prior to his initial participation in the project (baseline), at any time the monitoring team may desire during the project (periodic), and immediately after completing his last task in the project (follow up). Specific medical tests will be performed in accordance with the best currently available medical/scientific information on the effects of PCBs. The monitoring Team Leader may direct withdrawl of monitoring team participation in the project and recommend termination of project if the results of these physical examinations indicate excess PCB exposure in any one of the shipboard personnel.

B.4 PERSONNEL PROTECTIVE EQUIPMENT

Because of the potential health hazard relating to the sampling and monitoring of the incineration of liquid PCBs onboard the M/T Vulcanus, special safety requirements have been established to minimize hazards to monitoring personnel. Personnel must be protected against any contact with the liquid PCBs or possible hazardous combustion products.

To ensure adequate protection, disposable coveralls and shoe covers will be worn by all personnel working in areas of the ship designated as contaminated: pump room, incinerator room, and main deck. Monitoring team personnel performing sample recovery will wear protective gloves. All personnel will wear safety shoes. Hard hats will be required for all personnel in the test area.

In addition to the normal equipment used in this type of activity, the following items will be provided by the monitoring team unless otherwise stated.

1) Gas masks with canisters suitable for use with liquid PCBs, phosgene, or HCl (MSA Rocket Propellant Masks No. EP-86847; canister type GMC-S, P/N 05-84908).

2) MSA Model 1 monitoring kits, Universal Tester (P/N 05-83500) with phosgene gas sampling tubes (P/N 89890).
3) Portable personal monitors, MSA Model G or S pumps fitted with sample tubes containing Chromosorb 102.
4) Fire Extinguishers

   Ansul - Model CD-5
   Sentry - Model Sy-1012

5) Fire Fighter Entry Suits
6) Scott Air Pak
7) Portable Emergency Eye Baths

All monitoring team personnel who will be onboard the M/T Vulcanus during incineration of the liquid PCBs will be duly trained on the proper use and operation of the above equipment.

Other general safety requirements that will be adhered to are the following:

1) All personnel within the incinerator area and/or sampling area during the incineration of liquid PCBs will have an approved gas mask and canister attached to their persons and available for immediate use.
2) If an emergency condition is detected by the monitoring team, personnel in remote locations will be notified to don masks and to evacuate a given area. Simultaneously, team personnel will notify the ship's Master of the imminent danger. Conversely, if the ship's crew detect an emergency condition, they will immediately notify all other personnel onboard the vessel.
3) Personnel working in the incinerator area (changing the sampling probes, making connections to the sampling equipment, probe positioning, etc.) will wear entry suits.
4) Confirmed or suspected spills will be reported to the ship's Master for proper clean up.
5) Personal monitors will be located in appropriate areas of the ship.
6) During testing selected locations will be monitored for the presence of HCl gas with the Universal Tester. Monitoring will be conducted in the following locations: bridge, main deck, stern and combustion deck. Monitoring team personnel will be reponsible for these monitoring activities.

B.5 PERSONAL HYGIENE

Available data indicate that compounds may enter the human system through the skin. Other means of introduction include ingestion, inhalation, and contact with the eyes. Symptoms reported in persons suffering systemic PCB intoxication include chloracne, nausea, vomiting, weight loss, jaundice edema, and abdominal pain.

The concept of isolation of contaminated areas and preservation of "clean" areas will be utilized during incineration operations. An interface area will be maintained which will ensure the integrity of the clean area and the safety of personnel therein while isolating contaminated areas. Adherence to this concept will prevent PCB contamination of facilities suitable for eating, drinking, smoking, and sleeping. The routes by which personnel move should be so arranged that the entrance to the working areas and exits from the working area are separate, thereby preventing possible confusion and subsequent contamination of clean facilities.

The basic requirements for effective personal hygiene against PCB-containing materials are:

- Protection of personnel from vapor and liquid contact in the contaminated areas by source control and protective gear.
- Provision of disposable clothing and foot covers.
- Provision of disposal facilities at the interface region between the contaminated and clean areas.
- Provision for shower, hand, face and eye-washing facilities at the interface region.
- Provision of clean clothing and foot covering at the boundary of the clean area upon return to working areas.
- Instruction in the use of the cleaning and protective equipment and in methods of personal cleansing.
- Mandatory and enforced use of the above facilities and concepts.

A monitoring system for ensuring the cleanliness of areas such as the galley, mess room, living quarters, bridge, toilets, and passageways, should be developed and put into effect on a firm basis. A schedule of inspection of the clean areas should be established, and the results of the monitoring made known to the ship's Master. Activities such as eating, drinking and smoking must be limited to clean areas.

Finally, all working personnel should be made aware of the need for good personal hygiene and of the consequences to themselves and others of poor personal cleanliness and poor housekeeping. A training program should be developed and personnel should be trained in personal hygiene practices. The effectiveness of the program will depend on the degree to which personnel accept the training, willingly put the principles to use, and cooperate in preventing exposures. Personnel who are unwilling or unable to accept and apply the personal hygiene procedures should be excluded from contact with and entry to the working area by direction of the ship's Master.

B.6 SAFETY PROCEDURES AND MONITORING

The safety of all shipboard personnel will have top priority during the incineration of liquid PCBs onboard the M/T Vulcanus. As a minimum, the following safety precautions must be considered as they apply before, during, and after burn operations. Many of these safety precautions are adapted from procedures used on the Herbicide Orange project. They are grouped by participating organizations to define and emphasize areas of responsibility.

B.6.1 M/T Vulcanus

1) After loading of the waste, all waste tank openings and viewing ports shall be closed. A closed system shall be maintained such that vapors do not escape into the atmosphere for the duration of the operation, except if required for tank soundings.

2) Any liquid PCB spills, leaks, or residuals detected during and following loading operations shall be contained and decontaminated before the ship leaves port.

3) The system for measuring the tankage contents shall be sealed, if possible. A schedule of tank content measurement and rate of depletion shall be established.

4) The cause of apparently random and often severe vibrations from the incinerators at frequent intervals during previous waste burns shall be identified. Steps to eliminate this condition shall be identified and implemented.

5) Fugitive liquid PCB emissions from the waste pumping room or any other source shall be eliminated.

6) An automatic shut-off device shall be in operation on both furnaces, set to turn off the flow of liquid PCBs if the flame temperature drops below 1250°C.

7) The furnaces may be brought up to operating temperature at a rate consistent with ship's practice and experience using fuel oil. When a flame temperature of 1280°C has been reached in the furnace (using correlated thermocouple or optical pyrometer measurements) the feed stock may be switched over to liquid PCB. The practice of converting to liquid PCB feed by putting furnaces on stream successively should be followed. The temperature of the furnace as read at the control panel should not be allowed to drop more than 20°C at this time must be restored to at least the original level before the next burner is changed over to liquid PCB.

8) Monitoring of the furnaces for temperature and completeness of combustion shall be in effect during the changeover. The continuous record of temperature shall also be maintained during this time.

9) The operational controls and monitoring panels shall be manned at all times by a responsible individual to insure the incinerators are operating within desired combustion parameters.

10) A device for addition of ammonia to make a visible plume shall be installed and operable.

11) The speed and direction of the M/T Vulcanus during waste incineration shall be controlled in such a manner that the incinerator plume does not contact any part of the ship at any time because of wind (eddys) or any other reason. The M/T Vulcanus shall stay under the main propulsion all the time so that plume impingement on the ship may be avoided by proper vectoring of the ship with respect to wind direction changes. Additionally, if the ship must assume a course and speed to stay in the burn area and if that course and speed result in undesirable plume conditions for safe operation, then the incinerators shall be temporarily shut down or revert to fuel oil until safe conditions can again be met.

12) The Vulcanus should demonstrate the ability to remain in constant 24-hour communication with the on shore Test Director by voice and by code, using frequencies and channels appropriate to the area and to the conditions of transmission and reception. This requirement supplements but is not intended to supersede nor replace the existing communication equipment. Daily communication with the on shore Test Director shall be required reporting test progress and conditions. Emergency conditions shall be reported as soon as possible.

13) Personnel of the M/T Vulcanus shall brief all sampling and monitoring personnel regarding ship safety procedures and regulations. This shall include, but not be limited to, the assignment of lifeboat seating positions and at least one lifeboat drill.

14) The M/T Vulcanus shall comply with all applicable U.S. Coast Guard rules and regulations governing a ship of this class and specification.

B.6.2 Monitoring Team

1) Personal ambient air monitors shall be furnished by monitoring crew. These monitoring units shall be analyzed for PCB as required.

2) Appropriate first aid and medical supplies and trained medical personnel shall be available at operations headquarters to respond to emergency situations onboard the M/T Vulcanus. Such facilities shall also be available to all shipboard personnel while at the docking facility.

3) The M/T Vulcanus crew and any other personnel boarding the M/T Vulcanus shall be briefed by the monitoring Team Leader or his designate about safety precautions and the potential hazards of liquid PCBs.

4) Monitoring of the incinerator stacks for CO/CO$_2$ concentrations shall be carried out by the sampling/monitoring team. The CO/CO$_2$ determinations shall be used to assure that the desired degree of combustion efficiency (99.9%) is achieved during the incineration of liquid PCBs.

5) Sampling of the incinerator stacks for the determination of PCB emissions, if any, shall be carried out by the monitoring crew. The PCB levels in the incinerator stacks shall be determined onboard the M/T Vulcanus by the sampling/monitoring crew with the use of a benzene sampling train and a gas chromatograph. The maximum allowable PCB levels in the incinerator stacks shall be 5 mg/M^3.

6) An onboard ambient air monitoring system shall be used by the sampling/monitoring crew to monitor the PCB level in the crews quarters, the combustion room, and the deck areas to assure that the atmosphere does not contain materials at or above a prohibited level of concentration. These measurements shall not be limited to only the times when sampling is taking place. Measurements indicating the presence of PCB levels above 0.5 mg/M^3 shall be immediately reported and steps shall be taken by the M/T Vulcanus personnel to correct the situation.

B.7 FIRST AID

The first aid instructions in the event of chemical poisoning, as given in J.B. Bailey and J.E. Swift "Pesticide Information and Safety Manual" (University of California, Division of Agricultural Sciences, July 1968), are reproduced on the next three pages. These first aid instructions are applicable to chemical poisoning by liquid PCB formulations.

FIRST AID IN THE EVENT OF CHEMICAL POISONING

If you are along with the victim...

First - See that the victim is breathing; if not, give artificial respiration.

Second - Decontaminate him immediately i.e., wash him off thoroughly. Speed is essential!

Third - Call your physician.

NOTE: Do not substitute first aid for professional treatment. First aid is only to relieve the patient before medical help is reached.

If another person is with you and the victim...

Speed is essential; one person should begin first aid treatment while the other calls a physician.

The physician will give you instructions. He will very likely tell you to get the victim to the emergency room of a hospital. The equipment needed for proper treatment is there. Only if this is impossible should the physician be called to the site of the accident.

General

1. Give mouth-to-mouth artificial respiration if breathing has stopped or is labored.
2. Stop exposure to the poison and if poison is on skin cleanse the person, including hair and fingernails. If swallowed, induce vomiting.
3. Save the pesticide container and material in it if any remains; get readable label or name of chemical(s) for the physician. If the poison is not known, save a sample of the vomitus.

Specific

Poison on Skin

- Drench skin and clothing with water (shower, hose, faucet).
- Remove clothing
- Cleanse skin and hair thoroughly with soap and water; rapidity in washing is most important in reducing extent of injury.
- Dry and wrap in blanket.

Poison in Eye

- Hold eyelids open, wash eyes with gentle stream of clean running water immediately. Use copious amounts. Delay of a few seconds greatly increases extent of injury.

- Continue washing for 15 minutes or more.
- Do not use chemicals or drugs in wash water. They may increase the extent of injury.

Inhaled Poisons (dusts, vapors, gases)

- If victim is in enclosed space, do not go in after him without air-supplied respirator.
- Carry patient (do not let him walk) to fresh air immediately.
- Open all doors and windows, if any.
- Loosen all tight clothing.
- Apply artificial respiration if breathing has stopped or is irregular.
- Call a physician.
- Prevent chilling (wrap patient in blankets but don't overheat him).
- Keep patient as quiet as possible.
- If patient is convulsing, watch his breathing and protect him from falling and striking his head on the floor or wall. Keep his chin up so his air passage will remain free for breathing.
- Do not give alcohol in any form.

Swallowed Poisons

- CALL A PHYSICIAN IMMEDIATELY
- DO NOT induce vomiting if:
    1) Patient is in a coma or unconscious.
    2) Patient is in convulsions
    3) Patient has swallowed petroleum products (that is, kerosene, gasoline, lighter fluid).
    4) Patient has swallowed a corrosive poison (strong acid or alkaline products); symptoms: severe pain, burning sensation in mouth and throat.
- If patient can swallow after ingesting a corrosive poison, give the following substances by mouth. A corrosive substance is any material which in contact with living tissue will cause destruction of tissue by chemical action such as lye, acids, Lysol, etc.

For acids:	milk, water, or milk of magnesia (1 tablespoon to 1 cup of water).
For alkali:	milk or water; for patients 1-5 years old, 1 to 2 cups; for patients 5 years and older, up to 1 quart.

IF POSSIBLE INDUCE VOMITING WHEN NON-CORROSIVE SUBSTANCE HAS BEEN SWALLOWED

- Give milk or water (for patient 1-5 years old--1 to 2 cups; for patients over 5 years--up to 1 quart).
- Induce vomiting by placing the blunt end of a spoon not the handle, or your finger at the back of the patient's throat, or by use of this emetic--2 tablespoons of salt in a glass of warm water.
- When retching and vomiting begin, place patient face down with head lowered, thus preventing vomitus from entering the lungs and causing further damage. Do not let him lie on his back.
- Do not waste excessive time in including vomiting if the hospital is a long distance away. It is better to spend the time getting the patient to the hospital where drugs can be administered to induce vomiting and/or stomach pumps are available.
- Clean vomitus from person. Collect some in case physician needs it for chemical tests.

Chemical Burns of Skin

- Wash with large quantities of running water.
- Remove contaminated clothing.
- Immediately cover with loosely applied clean cloth, any kind will do, depending on the size of the area burned.
- Avoid use of ointments, greases, powders and other drugs in first aid treatment of burns.
- Treat shock by keeping patient flat, keeping him warm, and reassuring him until arrival of physician.

B.8 ANALYTICAL PROCEDURES FOR THE DETERMINATION OF PCBs ONBOARD THE M/T VULCANUS

B.8.1 Introduction

It is necessary to analyze stack, ambient air, and other samples for PCBs onboard Vulcanus to assure safe operation and as a first-cut verification of adequate destruction efficiency while incinerating.

The maximum allowable stack concentration of PCBs is 5 mg/m^3. The maximum allowable ambient concentration of PCBs is 0.5 mg/m^3 (8-hour average).

The onboard analyses for PCBs in the stack and the personnel breathing zone will be performed by gas chromatography using electron capture detectors. Stack samples will be taken by a benzene impinger stack sampling train. Ambient air will be sampled by grab samples.

B.8.2 Instrumentation

The stack will be sampled with a benzene impinger train. The sampling train consists of three serial benzene impingers (approximately 1050 ml of benzene) followed by two activiated charcoal traps and one silica gel trap. The stack sampling rate is 2 liters per minute for 1 hour, or 0.12 m^3.

A gas chromatograph equipped with electron capture detectors will be employed for the shipboard analyses. Under ideal conditions, a detection limit of 0.02 ng is expected. For shipboard operation, a detection limit of 0.1 ng is assumed. Assuming that 5 μl of liquid is the maximum sample size that can be accommodated by the instrument, the minimum detectable quantity translates into a minimum detectable stack concentration of 0.2 mg/m^3 (5 mg/m^3 required). That is,

$$\frac{0.1 \times 10^{-9}\ g}{5 \times 10^{-3}\ ml} \times \frac{1050\ ml}{0.12\ m^3} = 0.18\ mg/m^3,$$

assuming no evaporation of benzene from the impingers.

For an ambient air sample of 1 ml and an absolute detection limit of 0.1 ng, the minimum detectable quantity of PCBs in air is

$$\frac{0.1 \times 10^{-9}\ g}{1\ ml} \times \frac{10^6\ ml}{m^3} = 0.1\ mg/m^3$$

The foregoing calculations indicate that gas chromatography with electron capture detection is adequate for detection of PCBs in the stack and ambient air at the given levels of concern.

B.8.3 Procedures

The onboard gas chromatograph will be a temperature programmable dual column instrument with electron capture detectors. One injection port will be used for liquid samples, and the second injection port will be used for analyzing ambient air samples.

The benzene impinger samples will be analyzed for PCBs in order to obtain rapid, preliminary destruction efficiency data. Ambient air samples will be analyzed to determine whether the ship's personnel are being exposed to hazardous levels of unburned PCBs. Both analysis techniques will be tested with standard solutions of PCBs before placing the GC on the ship and during analysis of field samples.

Because of the high hazard potential and the absolute need for rapid analytical data, a backup identical chromatograph will be provided for use onboard the Vulcanus. Both instruments will be thoroughly tested and calibrated in the laboratory before installation on the Vulcanus. Both units will be tested and calibrated after installation and prior to actual incineration. Since the chromatographs will be operated at maximum sensitivity, an isolation transformer will be provided for each gas chromatograph to reduce electronic noise.

REFERENCES FOR APPENDIX B

1. NIOSH Registry of Toxic Effects of Chemical Substances. U.S. Department of Health, Education and Welfare. Richard J. Lewis Editor. 1978 edition. January 1979.
2. Fuller, B., J. Gordon and M. Kornreich, "Environmental Assessment of PCBs in the Atmosphere", Mitre Corp. Technical Report MTR-7210, Rev. 1, 1976.
3. U.S. EPA, Office of Toxic Substances, "Support Document/Voluntary Environmental Impact Statement and PCB Manufacturing, Processing, Distribution in Commerce, and Use Ban Regulation: Economic Impact Analysis", April 1975.
4. "TLVs Threshold Limit Values for Chemical Substances and Physical Agents in the Workroom Environment with Intended Changes for 1979", American Conference of Governmental Industrial Hygienists, 1979.
5. Young, A.L., J.A. Calcagni, C.E. Thalken and J.W. Tremblay. The Toxicity, Environmental Fate, and Human Risk of Herbicide Orange and Its Associated Dioxin. USAF OEHL Technical Report TR-78-92 prepared for The Surgeon General, USAF. October 1978.
6. Sax, N.I., Dangerous Properties of Industrial Materials, Fourth Edition, Vas Nostrand Reinhold Co., N.Y., 1975.